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ADVANCED DEVELOPMENT MODEL (FEASIBILITY TYPE) TACTICAL PAGE READER

SEMIANNUAL REPORT

By

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MARCH 1972

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13. ABSTRACT

This report describes work done and progress made during the first six months of the design and fabrication of the advanced development model (feasibility type) Tactical Page Reader. ~~(U)~~

Most of the progress ~~in this project has been~~ made in the areas of predicted greatest difficulty, where least was known and where it appeared that most development work was needed. Among these areas are self-scanning photodiode arrays and efficient reflectors and light sources to produce sufficient narrow beamed light with low power. Additionally, work has been proceeding with the refinement of general logic, methods of driving large MOS memories, efficient power supplies, document drive and control, optical alignment techniques and devices. Furthermore, progress ~~has been~~ made in more routine areas such as main frame design and general packaging, and specifying, obtaining and testing new LED arrays. ~~(U)~~ ( )

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13. Abstract (continued)

The method of scanning and the type of photodiode array have been selected. A 256 bit self-scanning diode array with diodes on one mil centers is our choice. The methods of mounting and precisely aligning seven of these arrays has been given our careful attention. (U)

In order to keep the power associated with the illumination as low as possible, a special reflector and lamp assembly has been developed. This reflector is a carefully designed two-piece cylindrical ellipse with the lamp filaments at one of the foci. The total power required for the lamps turns out to be considerably below the 100 watts maximum permitted. (U)

An enormous amount of memory is needed in this reader for the purpose of storing the line information before processing, and to store the character information for the whole page after processing. The video line storage takes 78,848 bits and the page buffer storage takes 65,536 bits. For the lowest possible power consumption, together with reasonable space requirements, we have decided to utilize MOS type dynamic registers. At 40 microwatts per bit, the combined power requirement of these two registers is 5 3/4 watts at the output of the power supply. (U)

The size of the machine, as the framework is now laid out, is 3 1/4 cubic feet, which is comfortably below the five cubic feet maximum set forth in the specification. This includes some space within the machine which can be used for contingency purposes. (U)

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1.1 LOGIC DESIGN

1.1.1 Input System

As the design of the Tactical Page Reader has been proceeding, certain modifications have taken place as new ideas or technical problems have come up. This has effected the input system in the following ways.

First of all, it was decided to design the scanning system using the photodiode array containing the most bits. Several months ago our choice was the relatively new IPL 7256 self-scanning photodiode array. This array contains 256 light sensing elements. Since each element covers close to 5 mils on the paper (actually 4.58 mils), our array can take care of 256 x .00458 or 1.173 inches. In order to fully cover an 8-inch line including tolerance margins at left and right edge, seven such arrays are necessary. The coverage of a line, therefore, is actually 8.2 inches with a .1 inch tolerance for characters in the extreme left or right positions. Therefore, the number of cells in the complete set of scanning arrays is 256 x 7 or 1792. See Figure 1.

When the Reticon Corporation more recently came out with a product line of self-scanning arrays, this laboratory proceeded to make electrical tests of the samples submitted. As a result of these tests and for reasons which will be discussed later, it was decided to use the Reticon RL-256D as the unit scanning array in the Tactical Page Reader.

Originally, the scanning arrays were intended to feed into the video image register directly after the video signals were digitized. However, our test results showed that degradation of input signals occurred when the Reticon 256D Array was scanned at 300 KHz. We, therefore, are using a serial parallel approach in which the array is scanned at approximately 60 KHz. See Figure 1. Here, each array feeds a video amplifier (A) followed by a quantizing circuit (Q) followed by a one bit storage cell (M). The resultant binary signals are stored in a 256 bit MOS dynamic shift register. After the receipt of the 256th bit in each of the seven MOS registers, the registers are momentarily connected in series. The accumulated information is transferred to the first row of the video storage register at high speed. After this transfer of 1792 bits, the arrays are once more connected in the sampling mode.

As per Figure 1, a total of 44 rows of 1792 bits will be available for storage. The input gating is so arranged that after the loading phase is completed the video information can be recirculated if necessary

When a complete line is stored in the video storage register, this information must be transferred to the character image register. The transfer takes place in the parallel to serial register shown on the right hand part of the diagram.

1.1.2 Character Image Register

In the original proposal, it was decided to use the 8-Bit MSI Storage Register SN 74164 as the unit for the active portion of the character image register. By active portion is meant that part that actually connects to the correlation matrix. The rest of the register would be taken care of by an MOS device.

The present design calls for using the type SN 74164 in both the active and inactive parts of the register. See Figure 2. This does away with the problem of using different clocking drivers (and timing) for the two parts of the register.

In addition, in order to conserve power, the low power version of the MSI register will be used. Each active register stage is connected to two inverters. One inverter takes care of the assertions and a second takes care of the negations.

The entire register consists of sixteen columns of 44 stages each, for a total of 704 stages. The serial shifting rate is approximately 1.2 MHz.

1.1.3 Overall Logic Flow

The overall logic flow is shown in the general block diagram, Figure 3. This diagram shows the general flow of information from input to output of the Tactical Page Reader with the present arrangement of various sub units and the sizes of most of the important registers in the reader.

This flow is from the information on the document picked up by the optics, to the 1792 bit long scanning arrays, to the single row buffer and then to the 44 x 1792 bit line image register. When the character line is detected, the contents of line image register connect through a parallel to serial converter to the character image register. The resistor matrices connected to the image register supply the character correlation information to the comparator where the best match decision is made. The "one hot" decision is converted to either ASCII or Baudot code by the encoder after which the code is stored sequentially in the input character line buffer. This is done on a first in, first out basis. The input character line buffer receives information from a correction keyboard as well as the reader proper. This occurs whenever the machine encounters a "can't read" situation which ends in a reject code.

The LED register, which connects to the Light Emitting Diode arrays, is the same as described in the original proposal except that it has been increased in length from 160 to 168 diodes. This permits the array to cover 8.4 inches.

The information in the input line buffer is transmitted after the receipt of each line (and after corrections, if any, are made) to the page buffer. The buffer size is 8192 x 8 = 65,536 bits. Available MOS registers come generally in 1024 bit lengths (1024 x 8 = 8192).

When transfer to the page or message buffer occurs, the line feed and carriage return signals are added and in addition the suppression of non-significant spaces takes place.

From the page buffer, character information is transmitted a line at a time to the output character line buffer. It is at this point that the output lines are left justified and where additional line feed and carriage return codes are added whenever the output line is too long for the teletype machine to handle. The output control determines the character rates to be used in transmitting information to the output device. These rates are manually setable by the operator.

The overall timing of the machine is the function of the timing generator shown in the left central portion of the diagram. The highest data rate in the machine is 1.2 MHz, and most other rates will be submultiples of the basic rate. For example, the rate at which the scanning arrays work will be 1.2 MHz ÷ 20 or 60 KHz. The rate at which information is transferred to the character image register is 1.2 MHz ÷ 45 or 26.5 KHz.

1.1.4 Output and Format Control

Because of significant changes in the output logic, this section of the machine will be described in more detail. See Figure 4.

1.1.4.1 On-Line Character Correction

As the characters are recognized, the appropriate codes enter the 100 character line buffer. Since 80 characters are the maximum permitted in a line, the size of this buffer is more than adequate. Should a reject occur on a particular line, the On-Line Character Correction scheme comes into play. At this point the reject flip-flop momentarily turns off the motor moving the document, and turns on the reject code detector. This detector inhibits information from transferring to the page buffer, and allows the end around circulation of the line buffer until the reject appears at the output. At this point, the operator must press the appropriate character on the keyboard. This action shifts the line buffer one position and inserts the proper code in the first position instead of the reject code. If there are no further rejects, the line buffer completes its recirculation until all characters are in their normal position, i.e., such that the character first in will be first out.

1.1.4.2 Non-Significant Space Suppression

This logic essentially eliminates all spaces to the right of the last legitimate character in a line. For messages with few characters in each line, this means a significant saving in transmission time. A character counter keeps track of the present count of all characters on a line including spaces. However, only the non-space character count is transferred to the block labeled down-counter. At the end of each line the down-counter, therefore, contains the position of the last legitimate

(non-space) character. The transfer of information to the page buffer takes place under the control of the down-counter and no further transfer takes place after the counter reaches zero count.

1.1.4.3 Normal Line Feed and Carriage Return

Immediately after the transfer of each line of data to the page buffer, it receives a line feed and two carriage return signals. The initial LF and CR signals, i.e., that series occurring before the first line, occur just before data is transferred from page buffer to output.

1.1.4.4 Space Justifying on Left Side of Line

This logic essentially takes care of justifying the line on the left side. As the first line is read, the number of spaces to the left of the first legitimate character (non-space) is recorded. After the second line is read, the number of left spaces is compared with that of the first line. If the number is less, only the smaller number remains. If the number is equal or greater, it is erased. This process continues until the page is completed, at which time the minimum count of all lines on the page is recorded.

When the page buffer is emptying into the output line buffer, these extra spaces in front of each line are eliminated by shifting the page buffer but not the output line buffer for the appropriate number of counts.

1.1.4.5 Extra Line Feed and Carriage Return

When the length of line in a particular message is longer than the particular Teletype device will take, e.g., 69 or 72 characters, extra LF and CR signals are necessary. This function is performed in conjunction with the output line buffer. Here, the number of characters per line is counted as they enter the buffer. If an overlength count occurs, it energizes the appropriate detection gate. Thus, as the line is shifted out of the output line buffer, shifting is stopped momentarily where a space occurs in the line, and extra LF and CR codes are sent to the output device. After this, shifting resumes, the remainder of the line is transmitted to the output device.

1.1.4.6 Letter-Figure Control (Baudot Code Only)

When the operator has set the TPR control so that it will convert character codes to Baudot, one extra data manipulation is made necessary. This is because of the required shift from alpha characters to numbers and vice-versa.

The plan now calls for performing this function at the output of the character line buffer. In the encoding, one extra bit is added to the Baudot Code to indicate alpha or numbers. This extra bit is detected at the output of the line buffer. Whenever the bit changes, normal shifting in the output line buffer will stop for one beat and the appropriate up shift code or down shift code will be inserted on the output lines.

This turns out to be the best place to insert the shifting codes for economy of equipment. Otherwise, the page buffer could theoretically double in size. This could-happen if the machine were reading 80-line messages where there occurred a continuous change from letters to figures and vice-versa; e. g., A1B2C3, etc.

1.2 SCANNING ARRAYS

1.2.1 General

The self-scanning arrays used in the TPR are one of the key components in the whole system. Basically, these arrays consist of a linear set of monolithic photodiodes used in a light integrating mode. Each photodiode has associated with it a field effect transistor by means of which one diode at a time may be switched to the output or video line. This switching is usually performed by a 2-phase shift register which commutates through the set of field effect transistors. All diodes, switching transistors, registers, etc. are on a single silicon chip.

At the time this project was started only two companies were providing such arrays commercially. Fairchild was one and IPL (Integrated Photomatrix Limited) was the other. The available arrays were limited in type and somewhat experimental. At the present time a third company is making self-scanning arrays, namely the Reticon Corporation. Although this field is far from mature, much more component choice and data is available now than when this project started.

Until several months ago, our choice was a 256 diode array made by IPL and designated the 7256. This is an array designed on 4 mil centers. As such the active area is over an inch in length and as might be expected such a chip is very expensive. Moreover, with a 256 bit array, seven such devices were necessary to cover an 8-inch line adequately. This compares with fourteen devices with which we would have to contend if the FPA 602 were chosen. The latter is the largest made by Fairchild and contains 128 photodiodes on 2.5 mil centers. It should be kept in mind that with more arrays, additional alignment fixtures and adjustments are necessary. In addition, each array has its own lens so that a seven unit system seemed definitely advantageous to a fourteen unit system.

When the Reticon Corporation entered the field we tested their samples. We have since chosen that company's product over IPL. The basis for the choice is as follows.

Among the arrays made available by Reticon was the RL-256D. This is also a 256 bit device so it has no advantage in this respect over the IPL 7256. We still have the alignment and adjustment problem of seven arrays. However, the cost of the newer device was only about 35% of the IPL array in the quantities required. The RL-256D uses one mil diodes (actually slightly less) on a one mil pitch. This permits the arrays to be packaged in a smaller ceramic case and allows the seven arrays to be placed in an in-line arrangement. This is a far better mechanical arrangement than is possible with the IPL 7256. In the latter case, the photodiode arrays must be offset with respect to one another.

The RL-256D also has the advantage that it uses two power supply levels used in other parts of the reader, viz., +5 volts and -12 volts. On the other hand the IPL array requires three voltage levels, viz., +5 volts, -18 volts, and -24 volts. The latter two are non-standard and are not used in the rest of the machine.

Another factor in favor of the RL-256D is that this particular device contains its own clock driver. As such the array can be fed by a TTL integrated circuit. The IPL 7256 requires specially designed drivers with discrete transistors.

The IPL 7256 is certainly better in one respect and that has to do with criticalness of alignment. For example, in aligning #256 cell of the first array with #1 cell of the second array, a larger photodiode makes adjustment easier. Achieving an accuracy of 1/10 of a unit cell translates to .1 mil with the RL-256D and .4 mil with the IPL 7256.

1.2.2 Characteristics of the RL-256D

According to manufacturers specifications of this array, it should operate between 1 KHz and 2 MHz. If the array is to feed directly into the video image register, the serial scanning rate comes to slightly greater than 300 KHz. However, from our experience, the output becomes degraded when the 256 bit diode array is operated above 200-250 KHz. This decrease in signal to noise ratio occurs because the signal is not given full time to recover. A recovery time of at least 4 μs for this size array seems necessary. Therefore, as previously noted, we are using a serial parallel approach in which the array is scanned at approximately 60 KHz.

On the sample arrays we originally tested, we noticed a marked odd-even effect. For example, all odd video signals would be of greater amplitude than the even signals by about 25%. We reported this to the manufacturer who indicated that this was due to light affecting the semiconductor structures connected to the photodiodes. In addition, there were end effects such that end diodes were more sensitive due to internal reflections in the scanning. These defects have since been corrected by the manufacturer by additional masking.

Noise spikes are another difficulty in using scanning arrays in general. These occur due to the fast switching transient at the leading and trailing edge of the clock pulses. We intend to minimize these effects by carefully tailoring the band pass of the amplifier since the noise spikes contain higher frequency components than the true signal. Also careful timing of the video signal will be used to further reduce the effects of this systematic type of noise.

Figure 5 illustrates typical wave forms associated with an RL-256D Reticon scanning array. Figure 5a shows the effect of an array crossing a 5 mil line. The full amplitude signals represent the white signal. The lowest amplitude signal represents the black crossing. Figure 5b

shows the effect of the same array crossing a 10 mil line. In this case, the modulation is increased. Figure 5c represents the relation of the digital start signal, the input clock signals and the output video. Notice the three blank pulse times before the video start. The manufacturer inserts these extra non-readout pulses in order to make the array more uniform. From our point of view, the timing and logic must take this into consideration. In this case, we must start successive arrays scanning three pulse times before the end of the last array. Figure 5d shows the time relation of the various clock phases which time the array.

In Figure 5a, b, and c, the basic clock rate is 50 KHz so that successive bits are 20 μs apart. In Figure 5d the clock rate is 100 KHz.

1.3 STORAGE REGISTERS

The Tactical Page Reader makes much more use of storage registers than most machines. This is principally due to the necessity of storing the video image before character processing takes place, and storing the entire results of the recognition process for the entire page.

For the very large registers, in particular those named above, we are choosing the Signetics type 2502-3-4. These are MOS dynamic registers with very low power dissipation per bit. The manufacturer rates this as 40 microwatts/bits at 1 MHz. The second important characteristic of these registers is the capacitance of the clock lines, since this effects the ease or difficulty in shifting the data. The clock line capacitance is 140 pf per 1024 bits. We intend to put a limit of 8192 bits on any one clock driver because of the coupling of clock lines within the MOS devices.

For the smaller registers, such as the input line buffer and output line buffer, we intend to use the Signetics type 2510 which is a dual 100 bit register. These are static registers and thus do not need the constant circulation required by the dynamic types. The clock capacitance is only 5 pf since the clock line is buffered. Power is greater in these registers, about 2.7 milliwatts per bit.

Both types of registers are compatible with TTL logic and with each other. Also both should work comfortably at the maximum rate in the reader, viz., 1.2 MHz.

1.4 POWER SUPPLIES

In building a reading machine with a low power requirement, it is necessary not only to use components with low power drain wherever possible but also to use power supplies with as high efficiency as possible. We originally considered the possibility of designing power supplies in our laboratory especially for the TPR. However, after a few experiments it became clear that this would take too much of our available manpower and we looked to commercial suppliers.

One type of supply that we tested is manufactured by the Aaron Davis Company. The particular supply has a nominal output of five volts and a current rating of 7.5 amperes. Line regulation is .1% for a 10% line change and load regulation is 1% from one-half to full load. The design is of the pulsed high efficiency type which the manufacturer claims can go as high as 85%. Our tests using graphical analysis to calculate input power, showed an efficiency of only 61% at half current output and 52% at approximately full current output. This apparently is due to higher core losses in the full load condition. On the positive side, this type of supply is small, compact, and meets load and line regulation and ripple specifications easily. However, we intend to look further into the possibility of obtaining higher efficiency.

1.5 GENERAL ELECTRONIC CONSTRUCTION

In the earlier ideas on machine construction, we considered the use of two rows of printed circuit cards to take care of all logical manipulation, data storage and control functions. The only other major piece of electronic componentry was the resistor matrix which was built in a rectangular metal frame located on the right hand side of the machine.

In our present design, we are utilizing a single row of printed circuit cards, except that these are larger than the earlier design. The size is 8-1/2 x 9-1/2 inches with the connector taking care of up to 172 inputs, outputs, and power levels. The primary function of the cards will be in the handling of machine data. There will be room for twenty-eight or twenty-nine cards. The list is as follows:

Video Image Register	4 cards
Character Image Register & Matrix	16 cards
Comparator Boards	5 cards
Line Buffer and Page Buffer	2 cards
Miscellaneous	2 cards

In this design it is interesting to note that the character image register and matrix are incorporated on the same boards. This makes for considerable saving in the multi-wire cabling that usually connects the character image register to the matrix and the matrix to the capacitor storage and comparator circuits.

The control circuits, oscillators, gates, timing generator, counters, etc. will be housed in two separate metal panel doors on the right side of the machine. Components in the control section of the machine will be connected by wire wrap.

2. MECHANICS AND OPTICS

2.01 LENSES

Originally lenses studied for this project were of two-inch focal length. We had planned to use a self-scanning array with a pitch of 4 mils. Since the horizontal pitch to be used on this machine is 4.58 mils, an optical reduction of 1.146:1 would have been required. Two-inch focal length lenses gave us optical and spatial parameters which were possible but lenses designed for optical ratios of approximately 1:1 are rare, particularly with focal lengths of about two inches. Most two-inch focal length lenses are designed for large ratio optical blow-ups or reductions. When we later chose to use a self-scanning array with a pitch of 1 mil, optical and spatial parameters were such that we were able to use shorter focal length lenses. We settled on a 28-millimeter lens which is a stock item. For this array, an optical reduction of 4.58:1 is required. Lenses designed to provide optical ratios near this value are more easily obtained than those designed for a 1:1 ratio. Of ten such lenses purchased, seven will be mounted on the machine and three will be spares. The lens is an f2.8 with a simple but adequate iris. A photograph of it is shown in the upper part of Figure 6. An important feature is its relatively small outside diameter permitting the reader to have seven such lenses and scanning array assemblies in line. Optical tests made so far with this lens indicate that it meets requirements.

2.02 SCANNING ARRAY AND LENS MOUNT ASSEMBLY

Figure 6 shows such an assembly. It also shows one of the lenses which screws into the lens tube which fits into the bottom of the base piece. The lens tube and the base piece can be seen at the right of Figure 6. Also, shown is one of the self-scanning diode arrays. It fits into the top of the mount assembly so that the sensitive region fits over the oval hole at the top of the mount assembly. This is visible at the left of Figure 6. The scanning array and lens mount assembly allows interchangeability of such assemblies within each reading machine and from one reading machine to another and from stock to reading machine. There are seven such assemblies aligned in each reading machine. Each will be located by one of seven sets of pins on a bridge of the optical mechanical frame of the reading machine. Each mount assembly contains all adjustments and clamps.

The base piece of each mount assembly is fixed relative to the bridge of the optical mechanical frame of the reader by pins and screws. All adjustments for each mount assembly are made relative to its base piece on a special fixture fabricated for this purpose. The special fixture is discussed elsewhere. The two set screws coming out of the end of the base piece of the mount assembly at a slight angle hold a lens tube in place. The axial postion of the lens relative to the plane of the paper and to the plane of the scanning array detection surface is adjustable. At the bottom left of Figure 6 near the penny is an Allen Head screw which tightens or loosens the clamp piece around the cylinder of the base piece.

The clamp and the pieces at its top which hold the scanning array are adjustable up and down the cylinder of the base piece. Thus the axial position of the scanning array relative to the lens and relative to the plane of the paper is adjustable. With suitable image sensor and fixture, image focus and size may be adjusted properly.

When the clamp of the mount assembly is loose it may also be rotated relative to the base piece. This is accomplished by adjusting two opposing hexhead screws mounted in threaded holes in the clamp and bearing against a post mounted in the base piece. One of these set screws can be seen in Figure 6 at about the same level as the clamp screw. Thus the line of 256 photodiodes on 1 mil centers is adjusted to be parallel to a standard on a fixture. The rectilinear adjustment of the self-scanning array in X and Y directions is accomplished by adjusting two sets of opposing set screws which bear against a post mounted in the clamp piece. The V grooves and slide block design permit only rectilinear adjustment relative to the clamp. Two special nuts at the top of the mount assembly tighten the slide blocks to the clamp.

2.03 FIXTURE FOR ALIGNING SCANNING ARRAY AND LENS MOUNT ASSEMBLY

Figure 7 is a photograph of this special fixture described in the previous section. With it, each scanning array and lens mount assembly may be adjusted so that they are completely interchangeable relative to accurately located pairs of pins. The reading machine will have seven such sets of pins for seven such assemblies. The fixture contains three such pairs of pins. The top of the fixture is equivalent to the bridge of the optical mechanical frame of the reading machine. A mount assembly is shown in place at the top. A target or object is mounted on a micrometer cross-feed. The target consists of two holes in brass shimstock. The holes are about 4.5 mils in diameter and 1.168 inches apart. That distance, which is 255 times .00458 inches, is the distance between the center of bit #1 and bit #256 in the horizontal scanning row at the paper. These holes must focus properly on the first bit and the 256th bit of the self-scanning array where they are actually 255 mils apart. Optical mechanical alignment by visual means using a reticle has been accomplished for focus and enlargement.

It has also been done using electronic means and a scanning array. Adjustments have not yet been made, however, for rotary alignment or X-Y rectilinear alignment of the scanning array because a new type scanning array has been received, and we are using the electronic circuitry to check it out and become familiar with its idiosyncrasies and characteristics. Checking for rotary alignment and X-Y alignment is accomplished by rotating the mount assembly so that the holes are fitted onto the opposite pins and shifting the target or object position with the micrometer stage to measure the deviation from absolute alignment. Corrections of half the deviations are made to bring the mount assembly close to absolute alignment. Several such iterations should accomplish the task.

2.04 SCANNING ARRAY OPTICAL ELECTRONIC TEST SETUP

Figure 8 shows a laboratory rig for determining optical electronic characteristics of the self-scanning array. Different object targets may be used of black patterns on a white background or white patterns on a black background. Line thicknesses of various widths may be used and positions carefully controlled. Different enlargements and/or reductions may be set and careful focus made electronically using a scope. Various light sources may be used such as the two projection lamps shown in Figure 8 or flood lamps held at a greater distance away to provide more uniform lighting.

2.05 LAMPS AND REFLECTOR

Much savings in power can be obtained if the source of light and its reflector were efficiently designed so that the page is illuminated along a narrow band for approximately eight inches across the page. The vertical resolution of 5.87 mils requires a band of illumination of 5.87 mils, theoretically. However, an effective width of illumination of approximately 60 mils appears to be a practical amount. This is approximately an order of magnitude larger than the vertical pitch. Originally it appeared that there were two useful types of reflector arrangements. One was a parabolic cylindrical reflector and a cylindrical lens. Most of the light will be reflected from the parabolic reflector in such a manner that a cylindrical lens will focus it to a narrow line at the focal point of the lens. Theoretically, this is an efficient system. Practically, however, results were quite mediocre. Another theoretically correct approach did give good practical results, however. In this one, the source of light is located at one of the foci of a cylindrical elliptical reflector and a band of illumination appears at the other focus of the ellipse. That will be the location on the paper of the row of bits to be scanned. A specially designed elliptical cylindrical reflector was fabricated in two sizes. The larger of the two turned out to be more satisfactory.

Several kinds of light sources were investigated. Ordinary and special fluorescent lamps were tested. None of them produced enough light to be usable in this project. Long line filament lamps were tested. The only one that might be of any use is the type that has a long straight filament under spring tension. However, the filament vibrated easily and thus created too wide a vibrating band of light. It was replaced by five discrete lamps, the filaments of which were in the line of focal axis of the cylindrical ellipse.

2.06 TEST FIXTURE FOR REFLECTORS AND LAMPS

Figure 9 is a photograph of this reflector shown in a test mount in which adjustments can be made and light measurements can be taken along the band of illumination as well as across the band at any of its longitudinal locations. Flat reflectors at the ends return to a useful position light which would normally escape.

The following adjustments are built into this test fixture:

a. Rotation of the cylindrical elliptical reflector around its focal axis.

b. Rotation of the reflector around the nominal location of the band of illumination.

c. Rectilinear distance between the focus of the reflector and the nominal location of the band of illumination.

d. Location of one of the flat end reflectors.

e. The flashlight type lamps can be revolved within their sockets for alignment of the filaments relative to the focal axis. The position of these lamps along the major axis of the ellipse can be controlled by use of washers under the rims at the base of these lamps.

A photocell is underneath a piece of shimstock which has a 4.5 mil hole. This feeds a microammeter where relative light values are read. The photocell is mounted in one slide assembly which moves across the band of illumination. The location of the hole across the band of illumination is read from a short scale mounted to a longitudinal slide. The location of the scan hole longitudinally is read from a long scale along the stationary base of the fixture. We have recently started to take data using this test fixture. Three representative sets of curves are shown in Figures 10, 11, and 12. In each set each curve represents readings along the band of illumination for a particular position across the band. Figure 10 is a typical set of runs with the lamp filaments perpendicular to the axis of the reflector. Figure 11 is a typical set of runs with the lamp filaments parallel to the axis of the reflector. The distance between lamps is 1-5/8 inches. The end reflectors should theoretically be spaced 13/16 of an inch from the end lamps, and should extend down to the plane of the paper. Since the end reflectors cannot be brought to the paper there will be a fall-off effect near the ends of the eight plus inches of the band of illumination. The fall-off effect can be reduced by bringing the end reflector closer to the end lamp as shown by Figure 12. In this case the distance is 13/32 of an inch which is 1/2 of the nominal distance. These results indicate that the elliptical cylindrical reflector should be made longer and that the distance between the lamps increased and that the distance between the end reflector and the end lamp should be less than 1/2 of the lamp pitch. We have, therefore, ordered material to make longer reflectors. Tests with this fixture will continue so that we may observe more parameters to permit a final design. This will produce a band of illumination more than eight inches long which is sufficiently uniform.

2.07 LED (Light Emitting Diode) CHARACTER REJECT INDICATOR

When one or more rejects occur in an imprinted line, the paper feed will stop when the line passes the scan row position. Slightly above and down stream from the stop position of the line containing rejects will be a row

of seven LED arrays, each one containing twenty-four light emitting diodes. Thus, there will be a continuous row of 168 LED's at a pitch of 50 mils. This is two per character and covers a line length of 8.4 inches. Each reject character on a line will have the LED nearest its center illuminated. Figure 13 shows two special LED arrays of this sort, one made by Ferranti Electric Inc. and the other made by Monsanto Company. The one on the left was mistakenly made with only 20 LED's. It uses discrete components made by this company which they have potted into a block according to specification. The one on the right has diodes affixed to a substrate, made specifically for this project. For the same electrical input the LED's of the array on the right are considerably brighter than those in the array on the left. The one on the right is, therefore, our tentative choice.

2.08 MOTOR CONTROL

The company that manufactured the stepping motor also manufactures a printed circuit control board for this motor. We have tested the board and it works quite well. It permits operation of the motor over a wide range of speed in forward and reverse. We will use two specific forward speeds and one reverse speed. Figure 14 is a photograph of a laboratory mockup using this motor and a drive platen with short pressure rollers. Also seen is the printed circuit board for controlling the speed and direction of the stepping motor. Power requirements are 30 volt center tapped DC supply with a maximum ripple of five percent. Current is one ampere.

2.09 KEYBOARD

The catalogues of twelve manufacturers of keyboards were studied. Most of them provide only reed switch operation at the key. Two used other forms of mechanical contact. Such devices are inherently noisy producing both electrical noise and electromagnetic noise. We contacted two manufacturers of keyboards which provide solid state pushbutton switches for their keys. We have tentatively chosen the one which uses the Hall effect for detecting when a key has been depressed. A number of questions remain regarding the keyboard layout. These will be resolved and a layout will be designed and ordered.

2.10 OPTICAL MECHANICAL FRAME AND ASSEMBLY

Figure 15 is a layout of the optical mechanical frame and assembly. At the top are the seven scanning arrays and lens mount assemblies. They rest on the bridge of the frame. The front view shows the optical relationship between the mount assemblies and their respective object areas below. The side or end view shows more detail of both the optics and the mechanisms. The object or scan row is along the top of the two-inch diameter drum which is coated with cast polyurethane and ground to final size. The drum is driven through a set of gears by a stepping

motor which moves in increments of 1.8 degrees or 200 steps per revolution. The gear set, which will have no backlash, will produce increments of .00587 inches at the paper for each 1.8 degree stepping increment of the motor. The paper will have two speeds forward. The read mode will be at one inch per second and the search mode will be at two inches per second. This will be accomplished by driving the stepping motor at two specific frequencies in the forward direction. They are 170.2 cps and 340.4 cps respectively. The paper will also be driven in the reverse direction for location purposes. This will be a single speed of one inch per second. The paper is held flat by two sets of pressure rollers across the entire length and spring fingers. These rollers bracket the scan row location and will not interfere with the optics. Depressing a handle will lift the pressure rollers releasing the paper and stopping the motor. In addition, registers and buffers will be cleared and the machine placed in a ready condition. This paper release mechanism is depressed in order to remove the paper before reading is completed. Normally, paper is hand fed by placing it on the loading platen and edging it against the left side. The front edge of the paper is started up between the drive platen and the first set of pressure rollers. The reader takes it from there. The elliptical cylindrical reflector can be seen in its approximately correct location. Its design, however, has not been finalized. Paper edge detectors will be provided to determine when a specific location on DD Form 173 (OCR) has passed under the scan row. Each one will consist of a light emitting diode which produces light in the infrared range and a matching photo detector for the same range.

2.11 GENERAL PARTS LAYOUT

Layouts for the main frame of the Tactical Page Reader are shown in Figures 16, 17, and 18, the latter being a top view. To accommodate a quantity of perhaps twenty-eight or twenty-nine large printed circuit boards in one section there are actually two main frames connected by a hinge and a clamp. Below the page loading deck is the section for the large printed circuit boards. For servicing purposes, both ends of each board must be available: one end so that each board may be removed from its socket and the other end so that contact may be made with the wiring at the backs of the sockets. The top view, Figure 18, shows this section with its hinge at the right connecting it to the other frame and a fastener or fasteners at the left to hold it in the closed position. The frame with the large printed circuit boards can be swung out around the hinge at the right to get at the leads at the backs of the sockets. The printed circuit boards are removeable from the front. The cable to this section comes through near the hinge at the right. These large printed circuit boards contain most of the storage registers and the resistor matrices. Among such groups of storage are the page buffer, the character image register, and the video image register. They also contain the comparators which logically follow the resistor matrices. The top view, Figure 18, and the side or end view, Figure 16, show two wired panels arranged as doors. They are on the right side of the machine toward the rear. These wired panels, which contain most of the control circuitry and timing generators for the machine, swing out on hinges

after a side cover has been removed. The panels hinge away from the machine and also hinge apart from each other. The optical mechanical frame layout with the scanning mounted assemblies and the page drive mechanisms are shown in correct position relative to the main frame. This portion is discussed elsewhere in this report. Below the exit ramp and to the left of the wired panel doors is a chamber which will contain the power supplies. The chamber above the exit ramp will contain printed circuit boards and wired boards with circuits for motor control, LED reject character display, self-scanning arrays and associated buffers, the control panel and the keyboard. The keyboard and the control panel are not shown because choice of keyboard layout and circuitry have not been made. However, these units will be located at the top front of the machine.

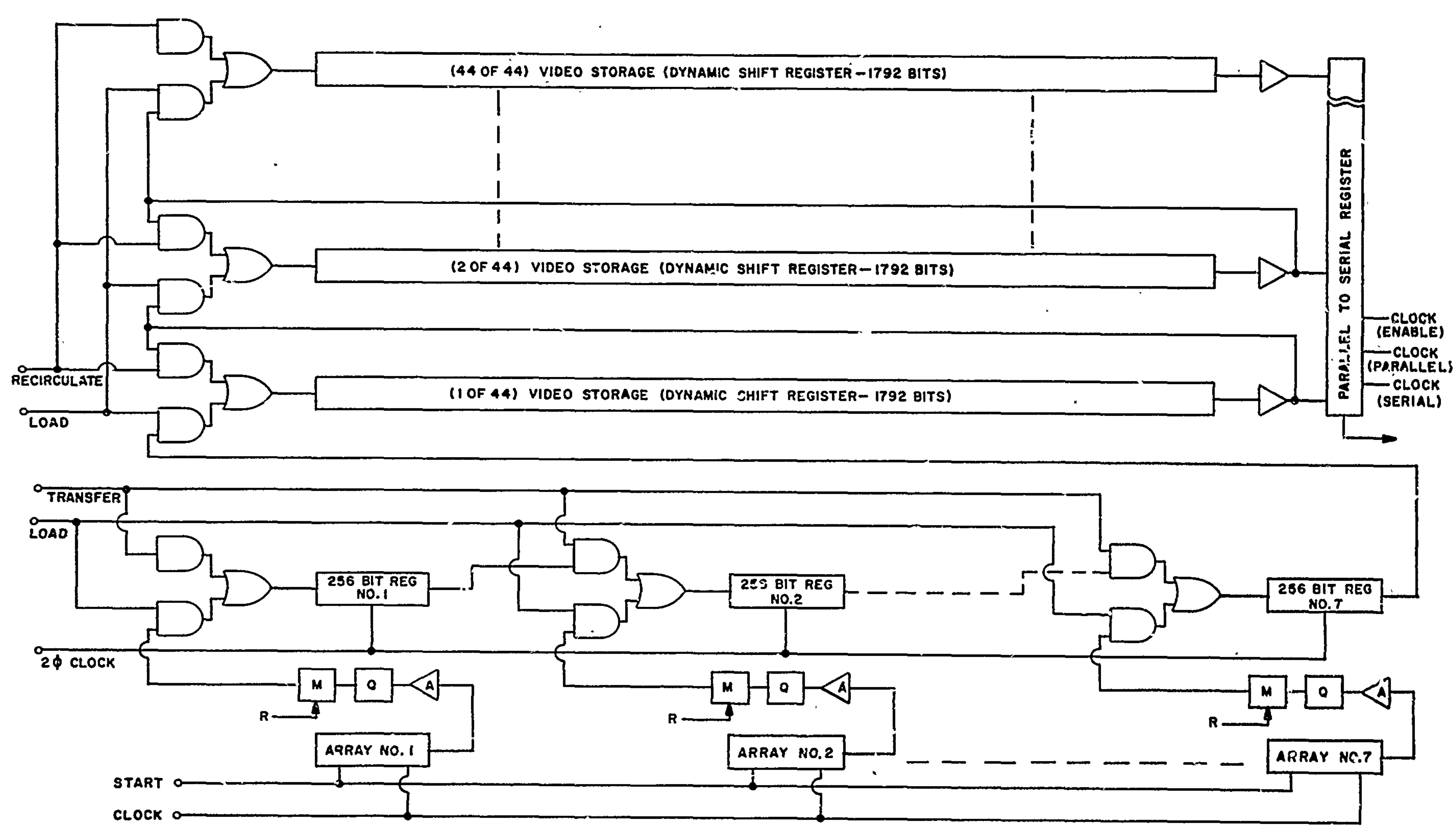


Figure 1. Self Scanning Photo Diode Array and Line Image Register

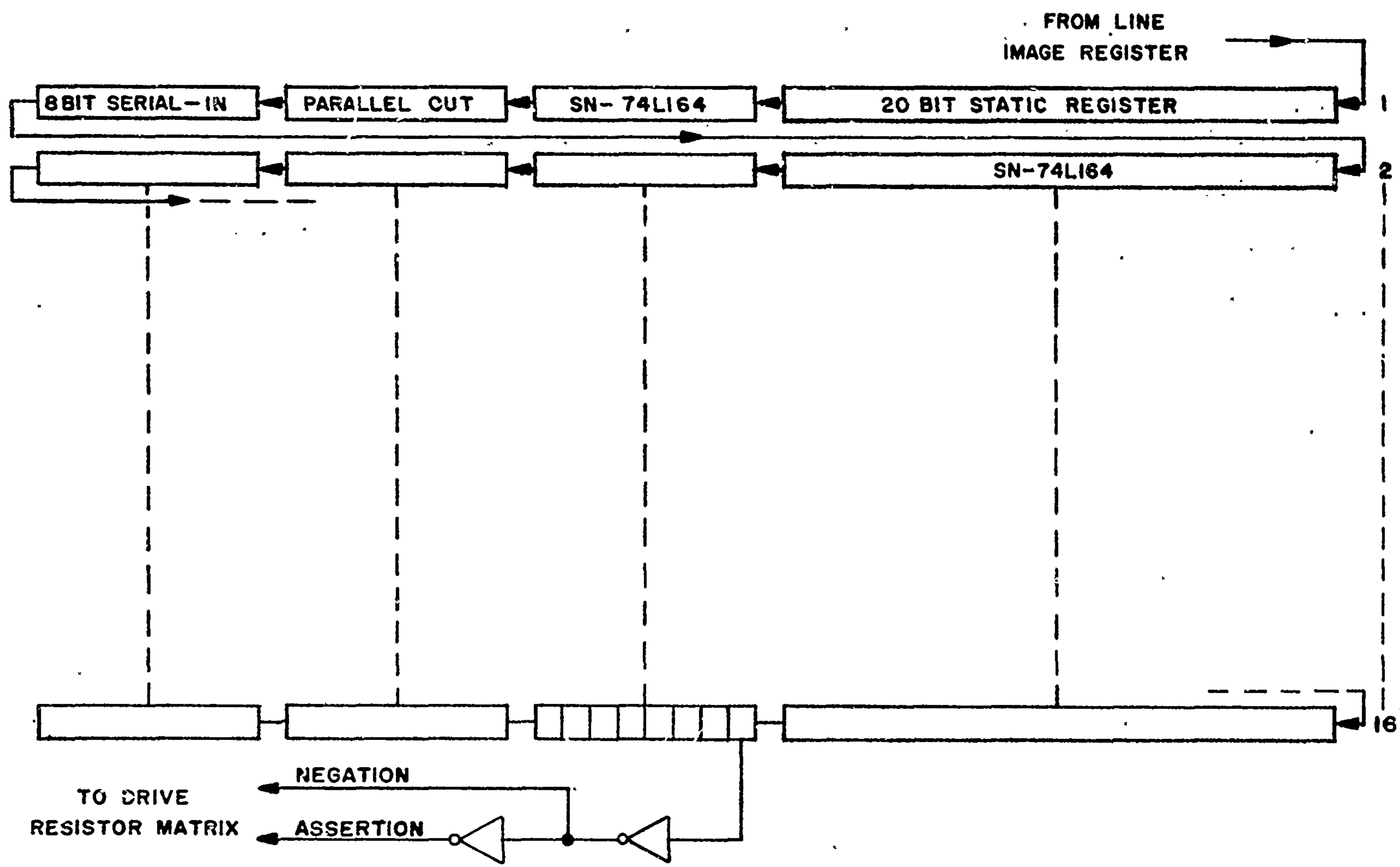
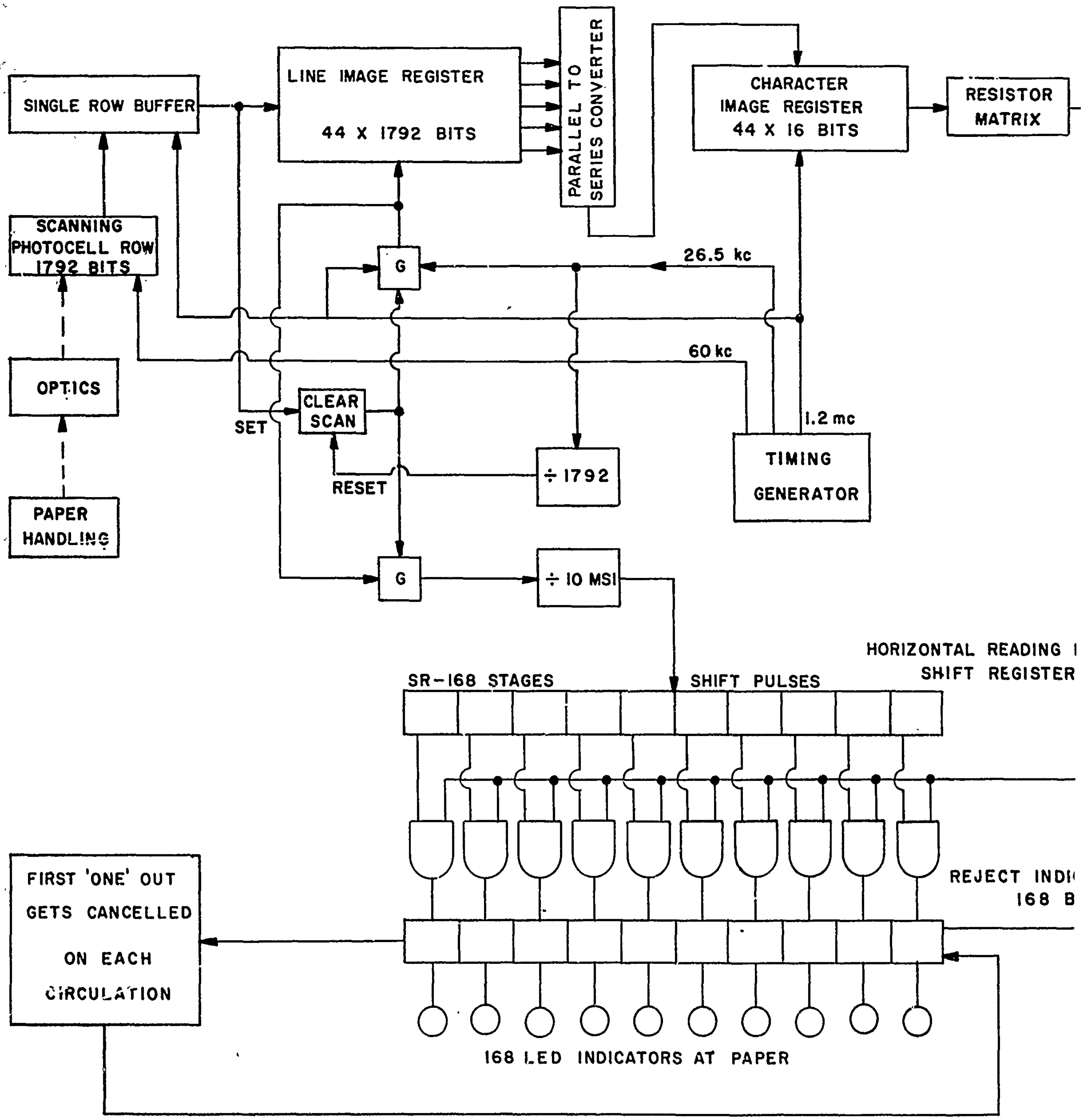


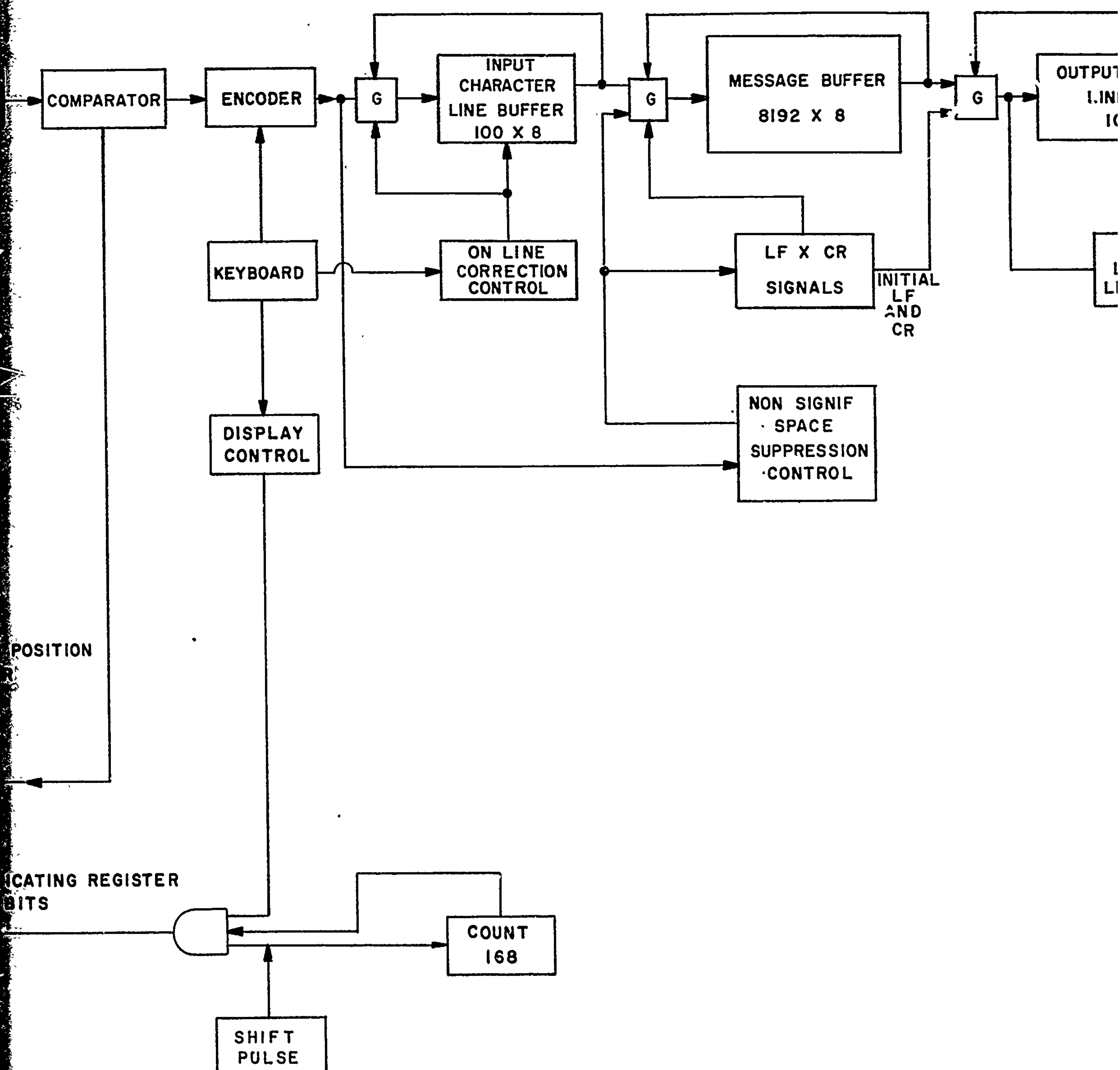
Figure 2. Character Image Register

A



SINGLE ROW BUFFER
LINE IMAGE REGISTER
44 X 1792 BITS
PARALLEL TO SERIES CONVERTER
CHARACTER IMAGE REGISTER 44 X 16 BITS
RESISTOR MATRIX
SCANNING PHOTOCELL ROW 1792 BITS
G
26.5 kc
60 kc
OPTICS
CLEAR SCAN
SET
RESET
÷ 1792
1.2 mc
TIMING GENERATOR
PAPER HANDLING
G
÷ 10 MSI
HORIZONTAL READING
SHIFT REGISTER
SR-168 STAGES
SHIFT PULSES
REJECT
FIRST 'ONE' OUT GETS CANCELLED ON EACH CIRCULATION
168 LED INDICATORS AT PAPER

B



COMPARATOR
ENCODER
G
INPUT CHARACTER LINE BUFFER 100 X 8
G
MESSAGE BUFFER 8192 X 8
G
KEYBOARD
ON LINE CORRECTION CONTROL
LF X CR SIGNALS
INITIAL LF AND CR
NON SIGNIF SPACE SUPPRESSION CONTROL
DISPLAY CONTROL
POSITION
COUNT 168
SHIFT PULSE

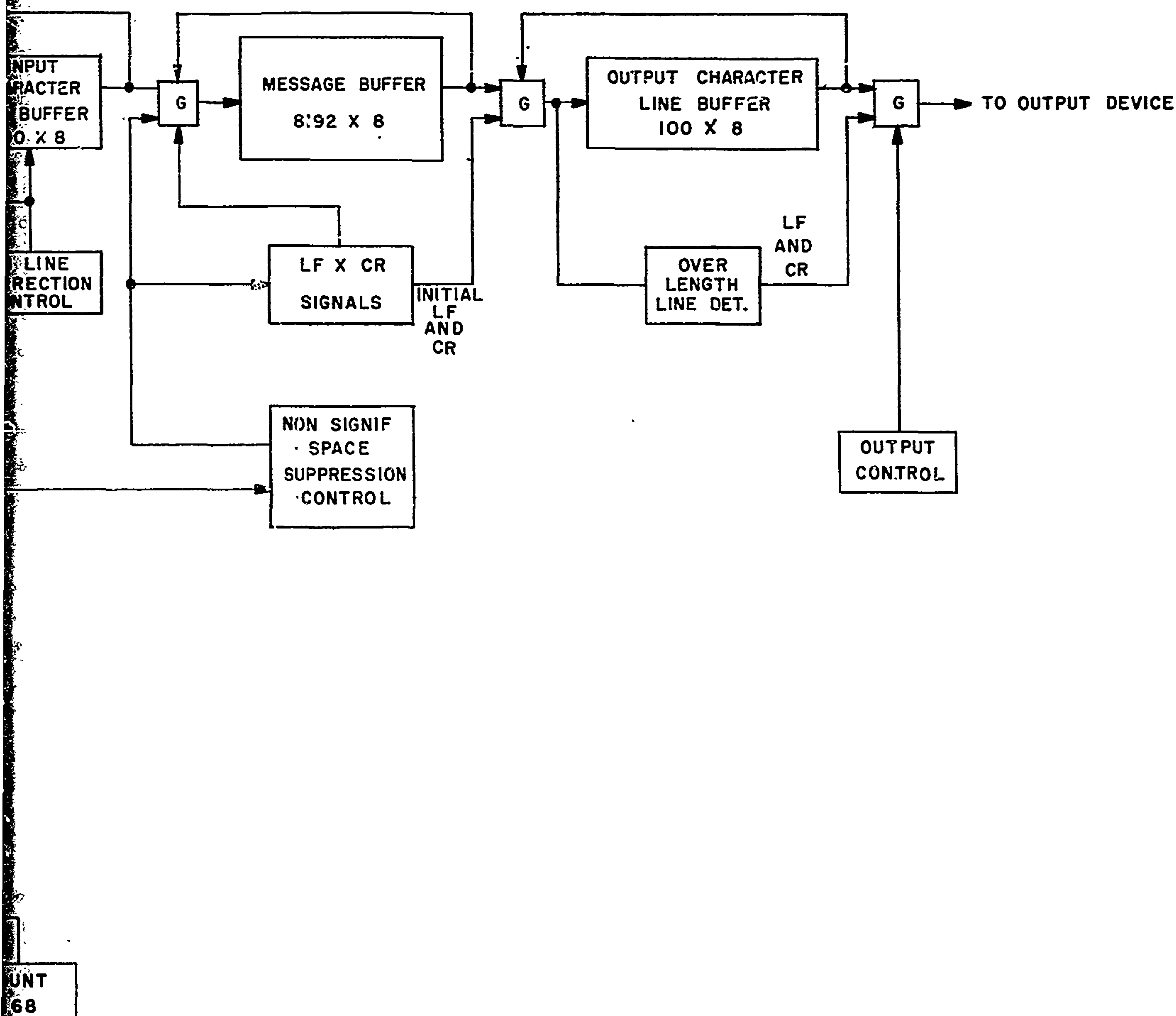


Figure 3. General Block Diagram

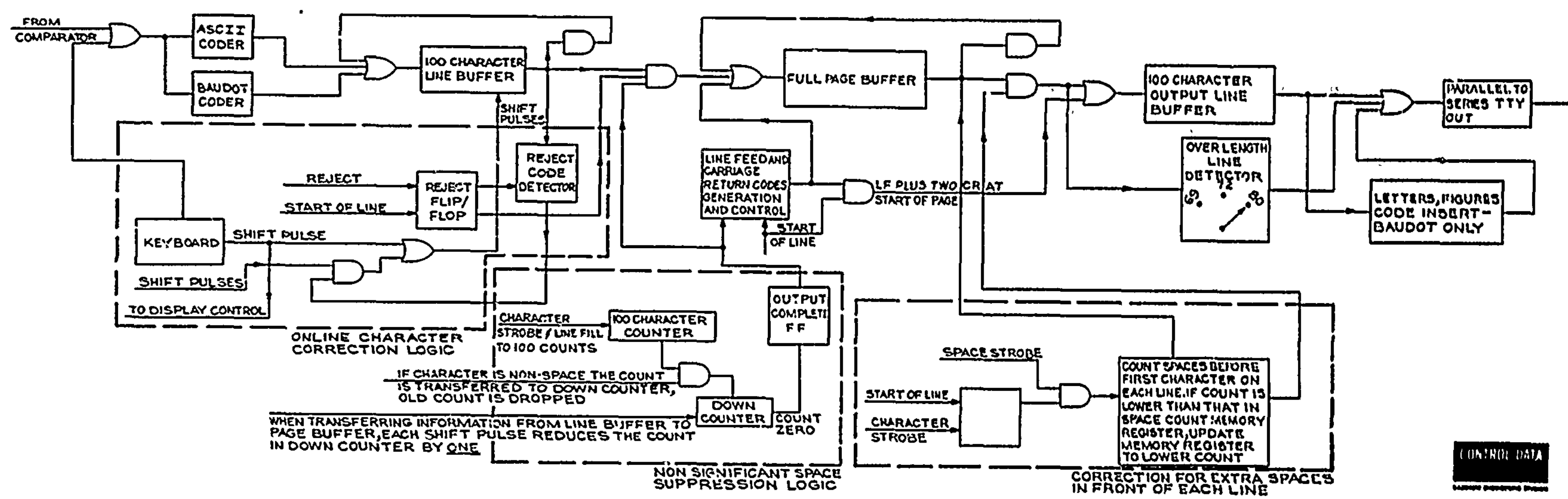
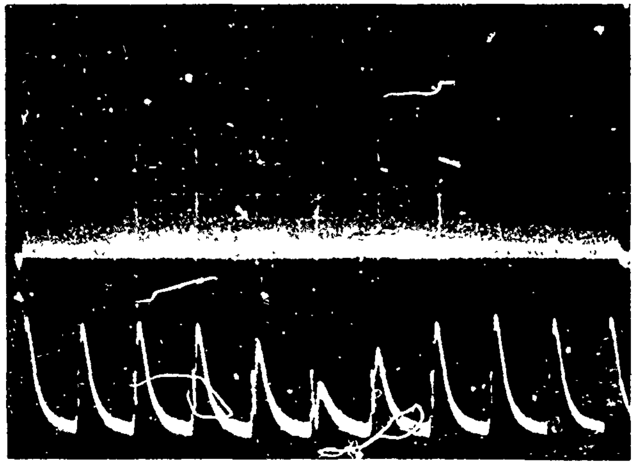
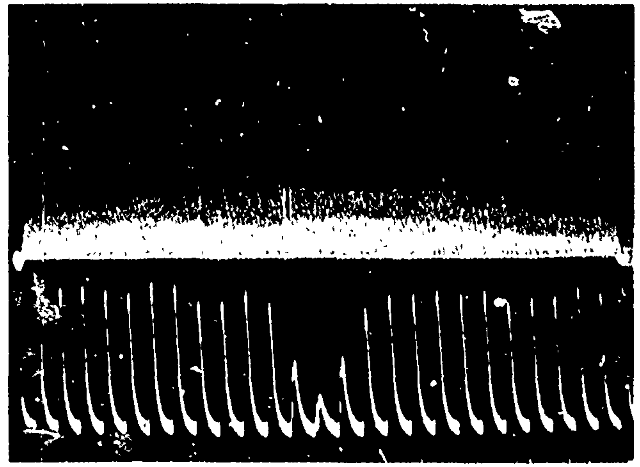


Figure 4. Output Logic and Control

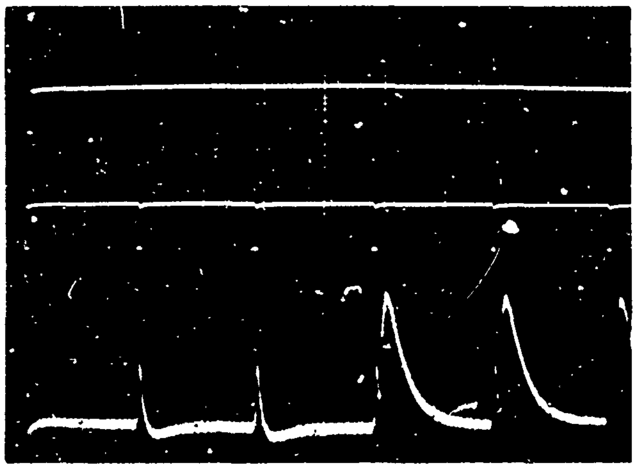


A. SCANNING ARRAY CROSSING 5 MIL LINE



B. SCANNING ARRAY CROSSING 10 MIL LINE

C. TIME RELATION OF START, CLOCK, AND VIDEO SIGNALS



D. TIME RELATION OF EXTERNAL AND INTERNAL START AND CLOCK SIGNALS

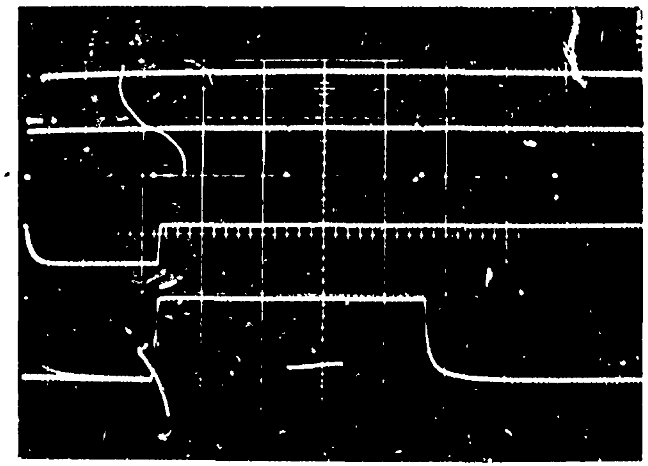


Figure 5. Scanning Array Waveforms

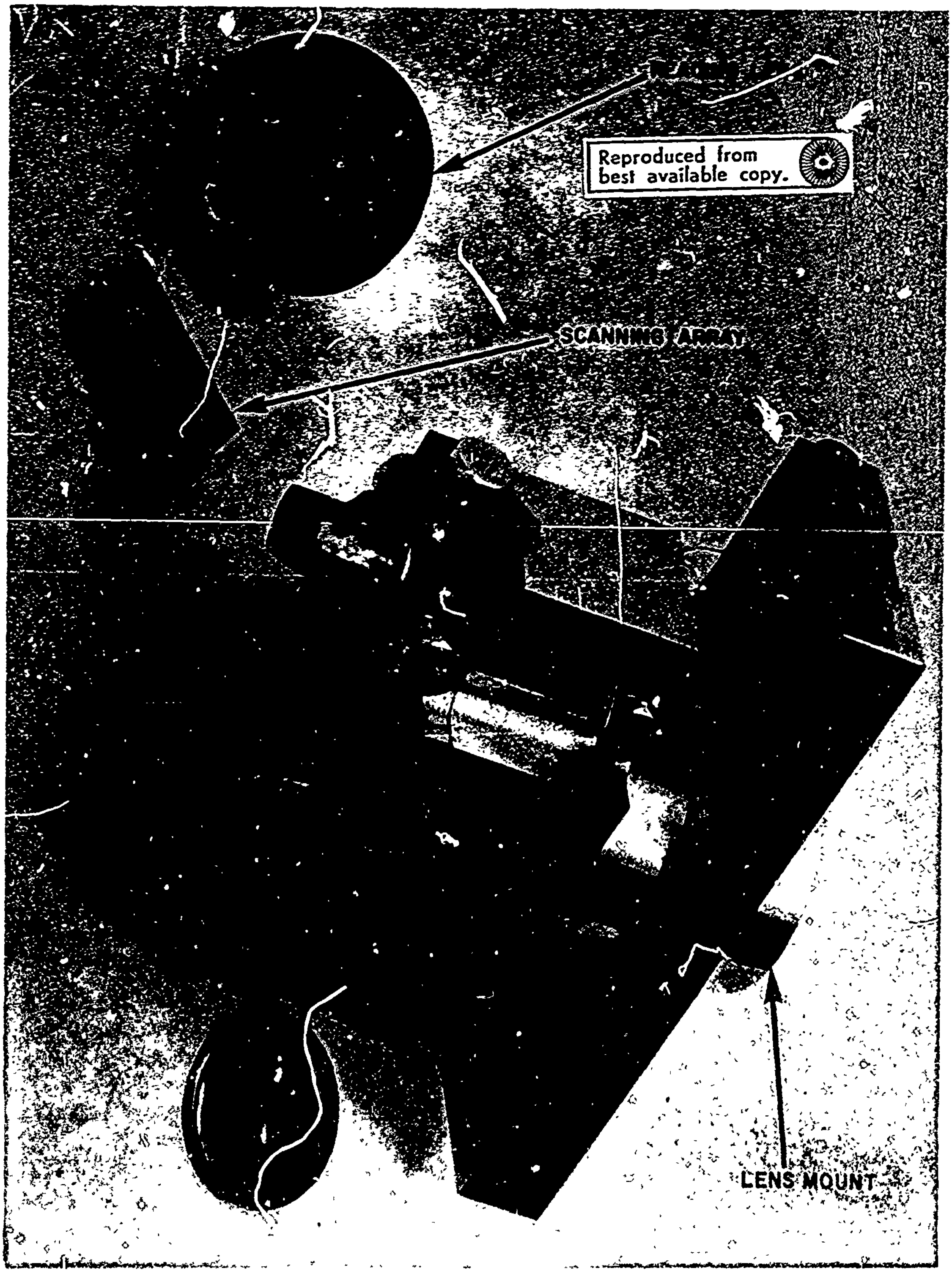


Figure 6. Scanning Array and Lens Mount Assembly

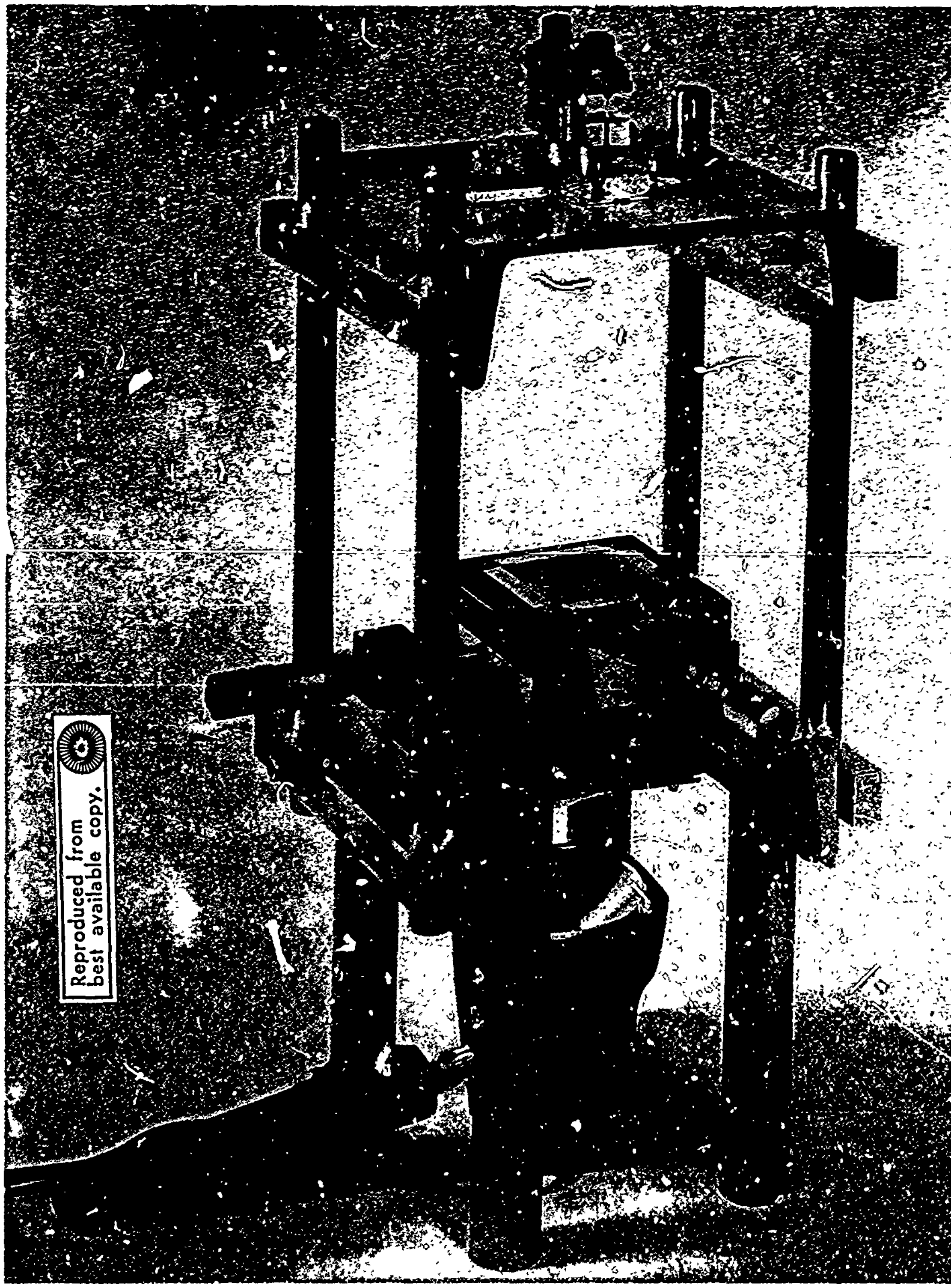


Figure 7. Fixture for Aligning Scanning Array and Lens Mount Assembly

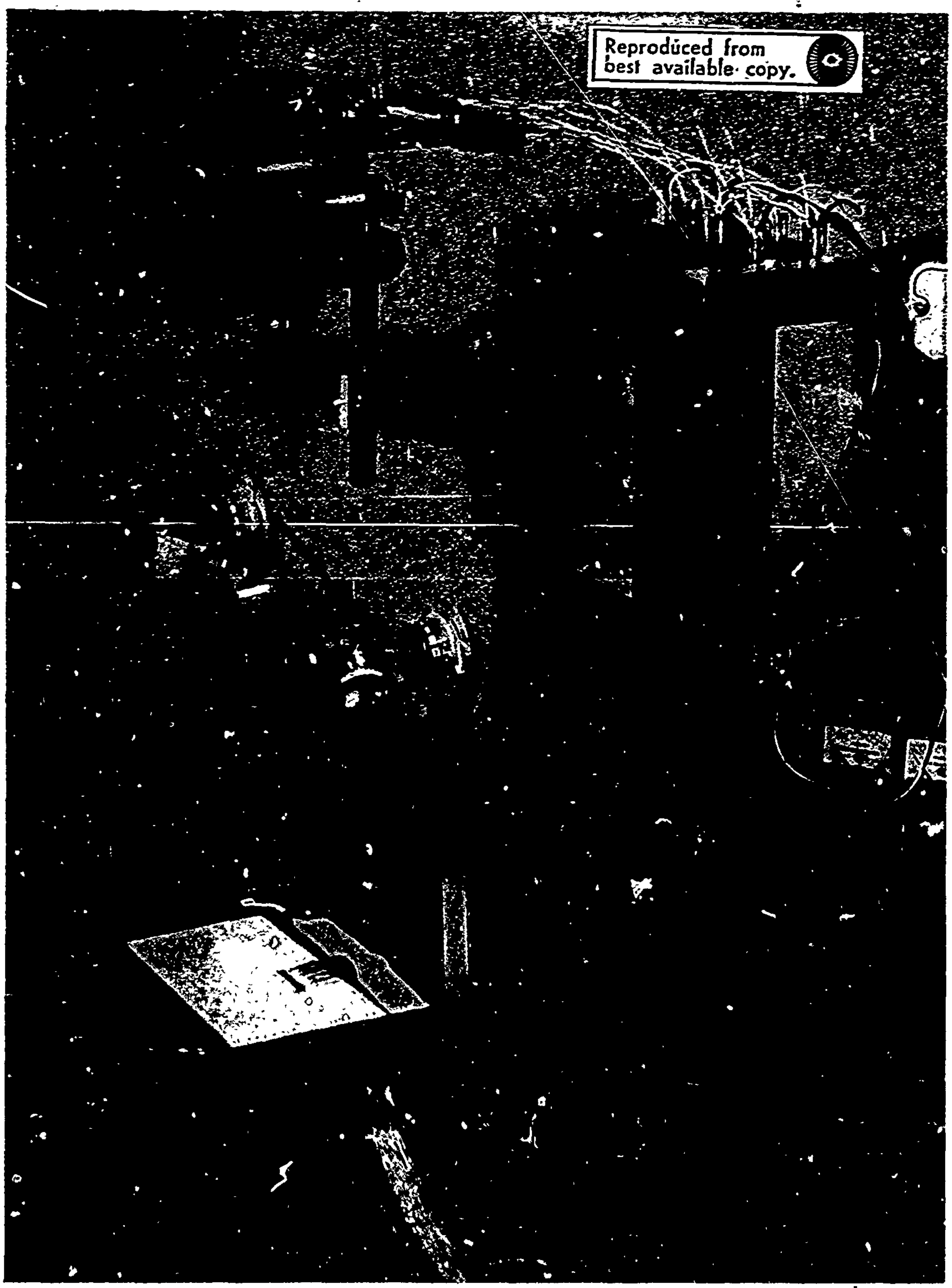


Figure 8. Scanning Array Electronic Test Setup

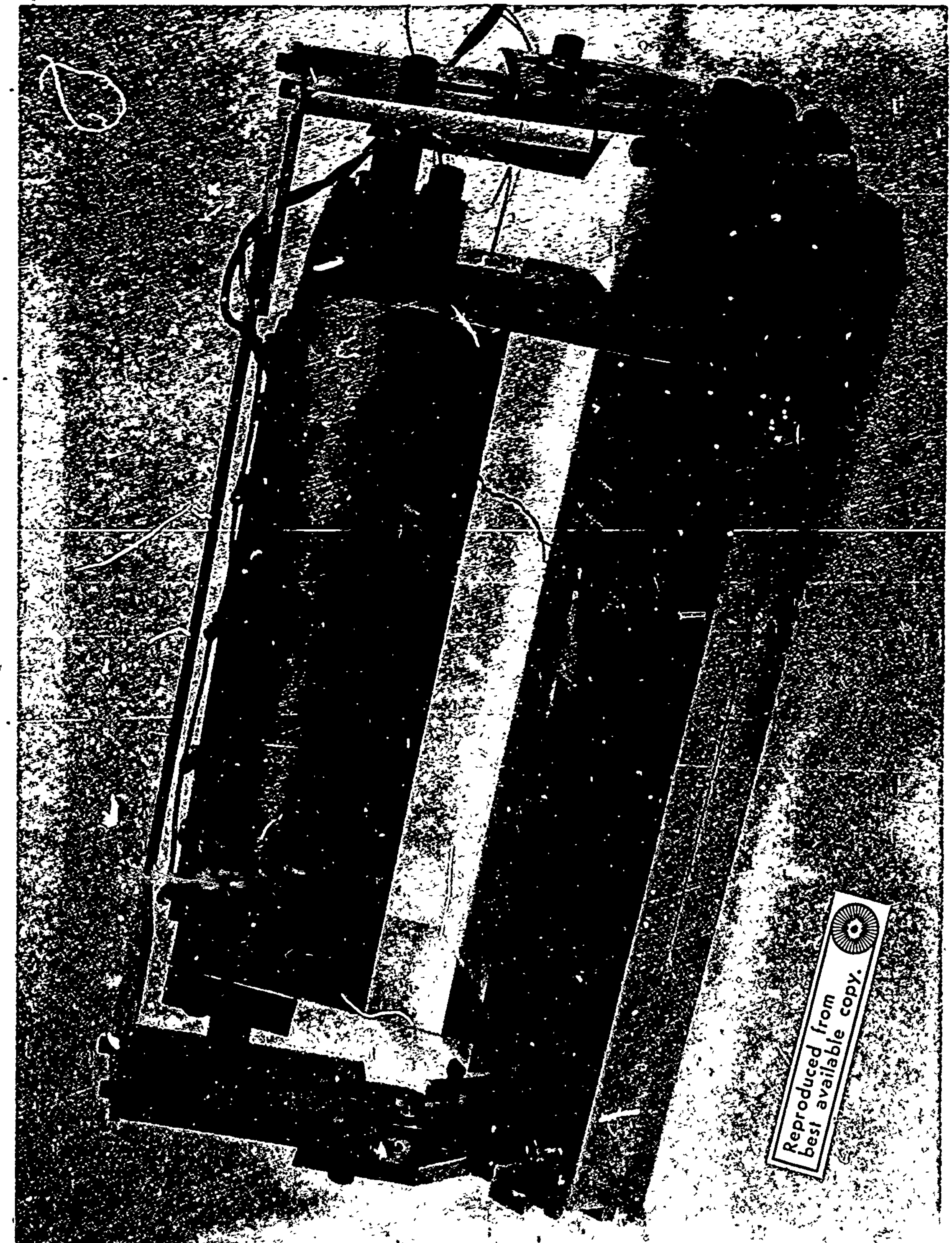


Figure 9. Test Fixture for Reflector and Lamps

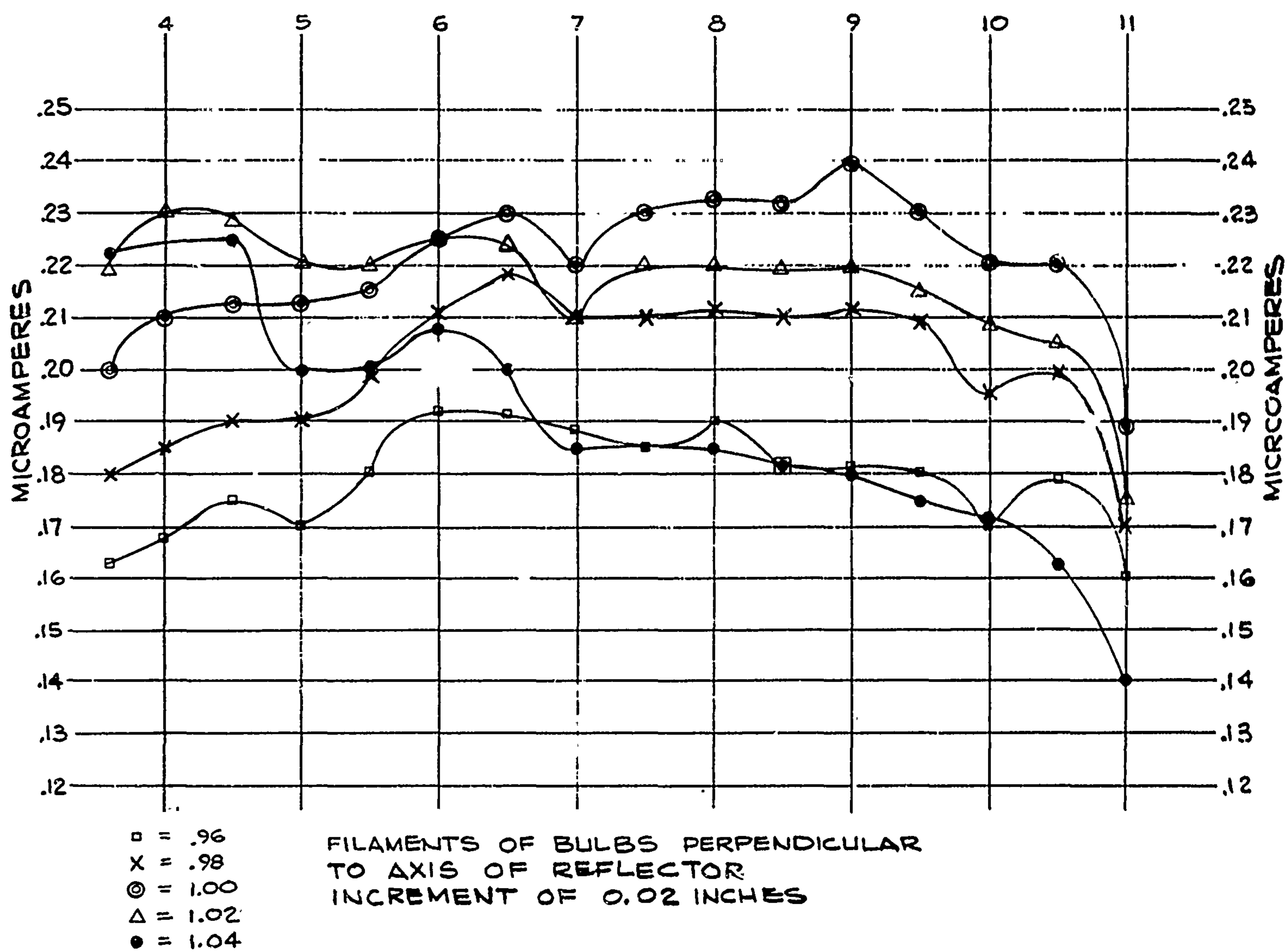


Figure 10. Illumination Band, Perpendicular Filaments

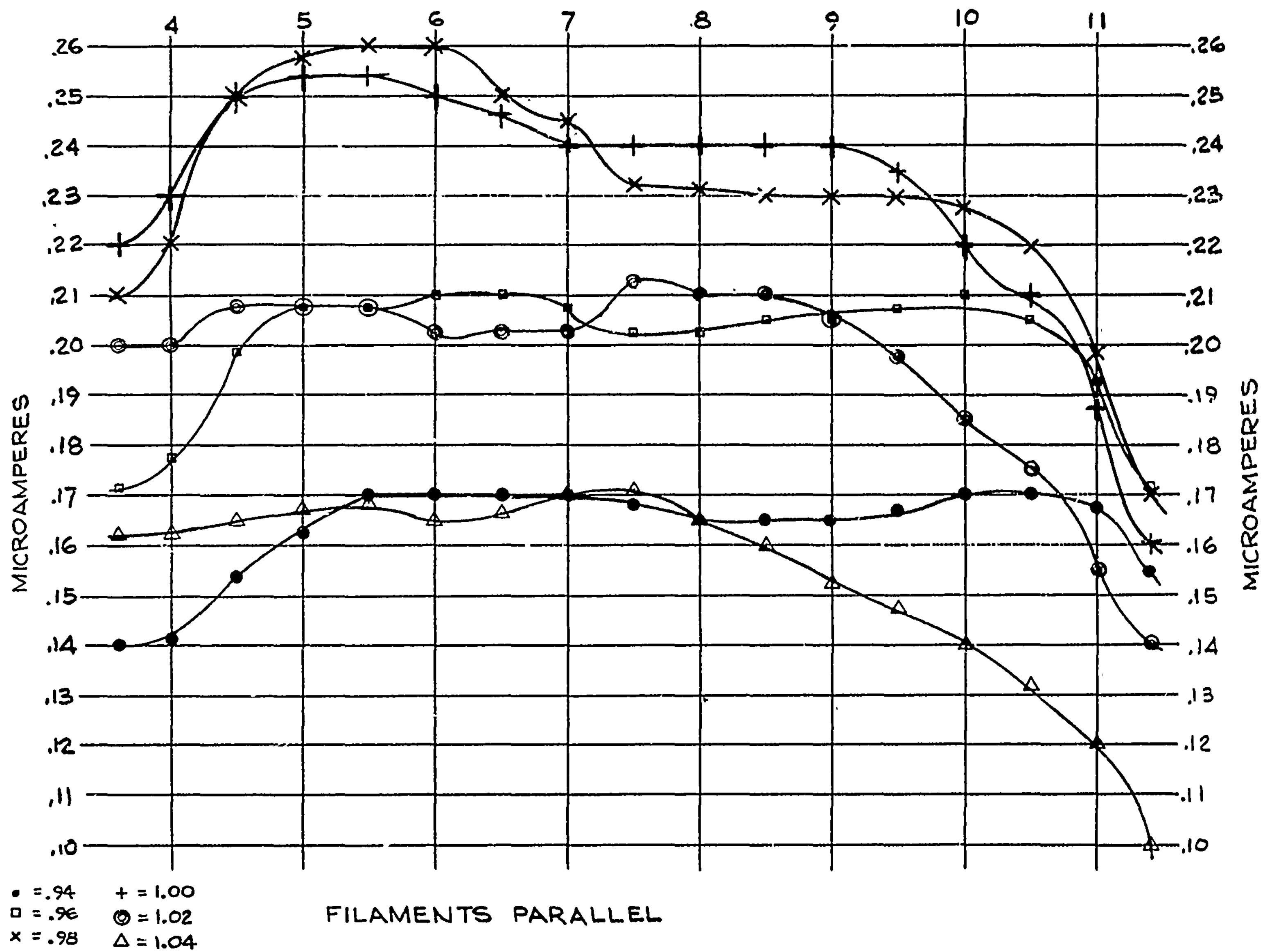


Figure 11. Illumination Band, Parallel Filaments

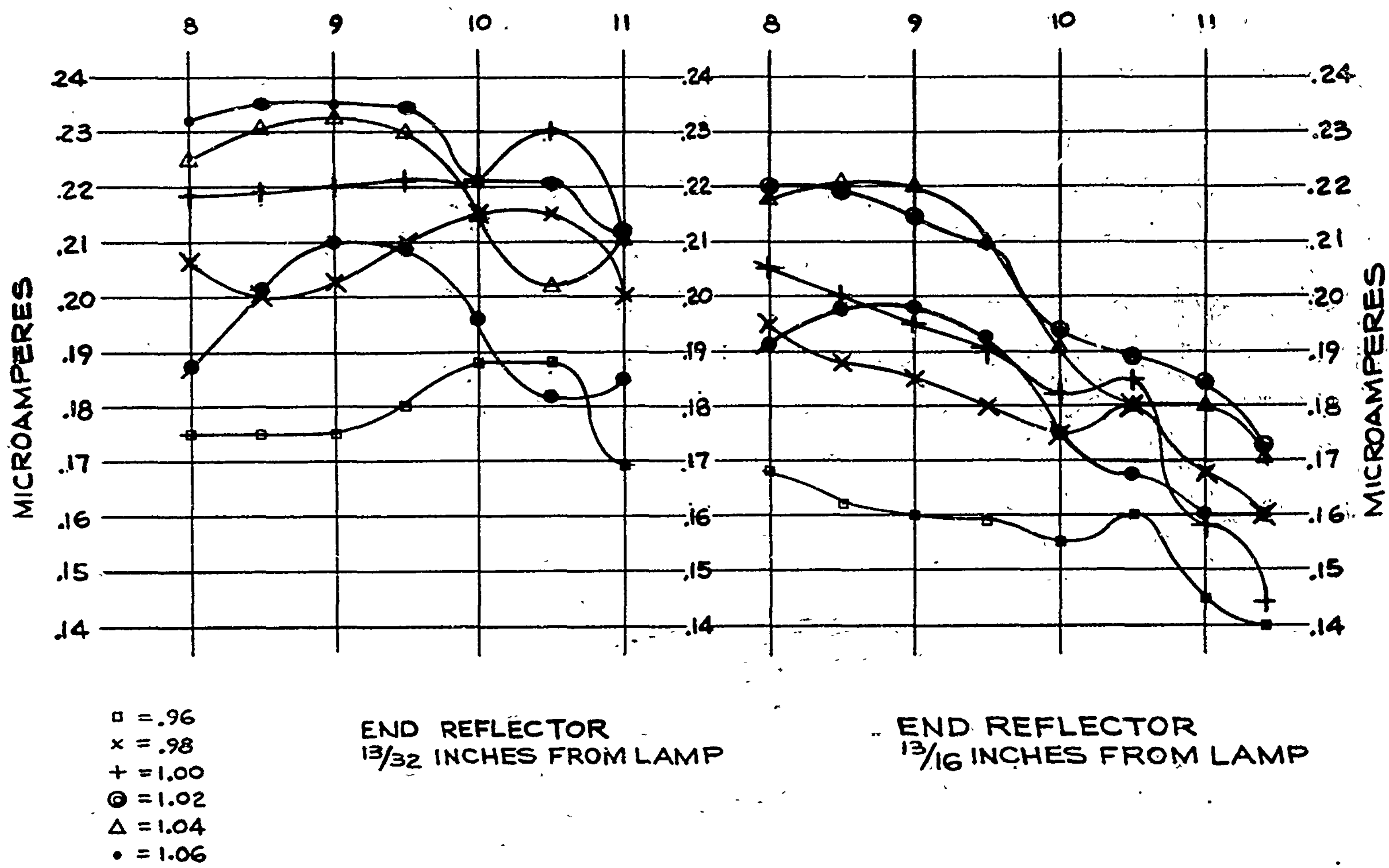


Figure 12. Fall-Off Effect

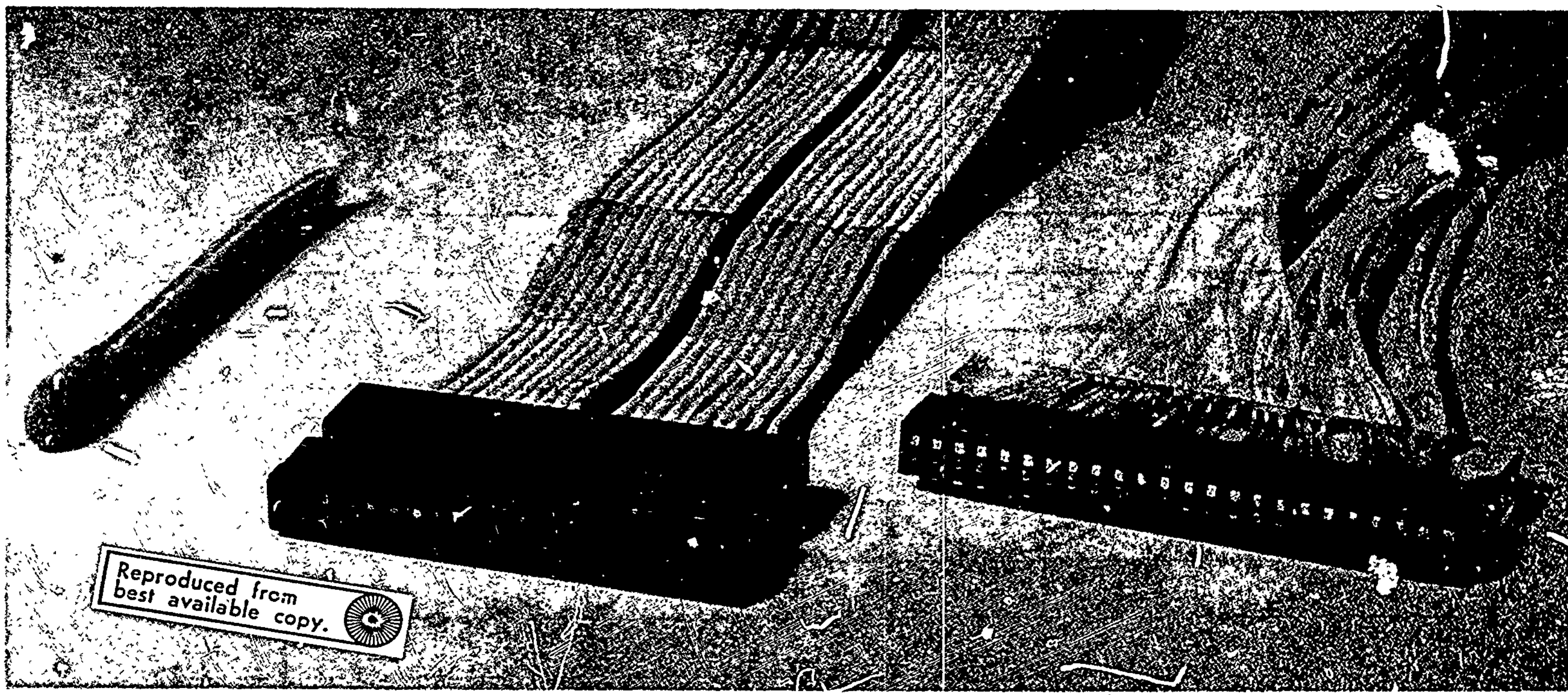


Figure 13. Special Prototype LED Arrays for Reject Correction

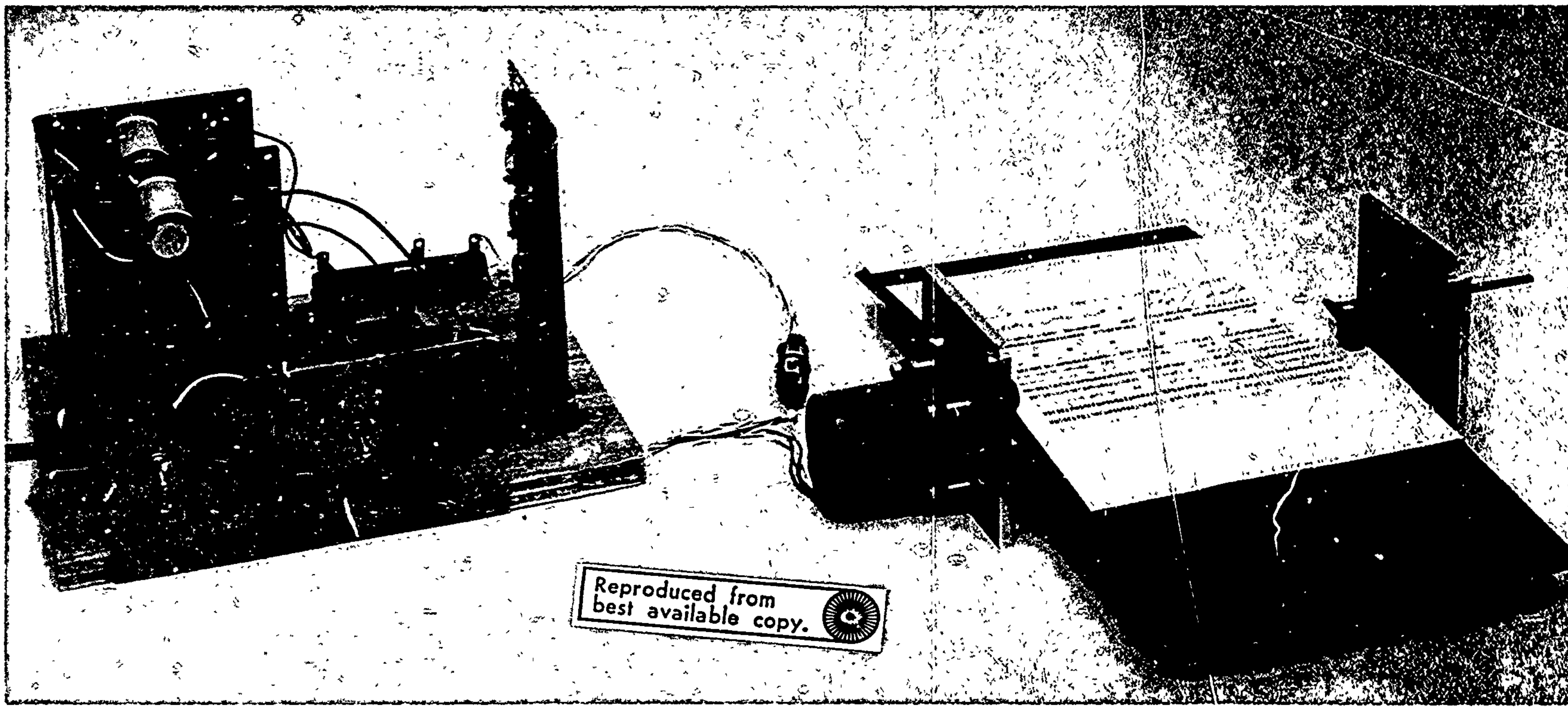
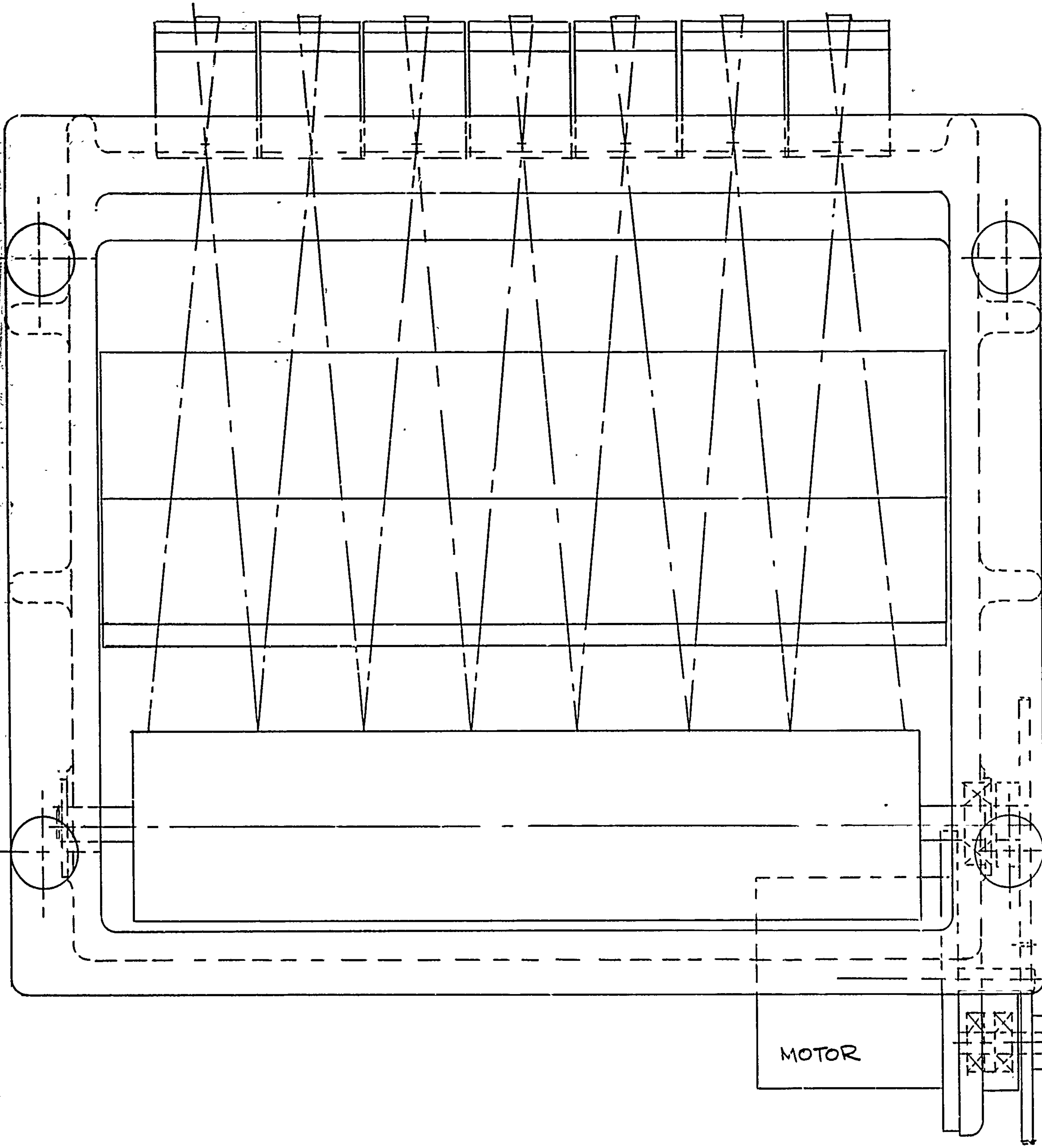


Figure 14. Laboratory Mock-up of Actual Motor Drive System


MOTOR

B

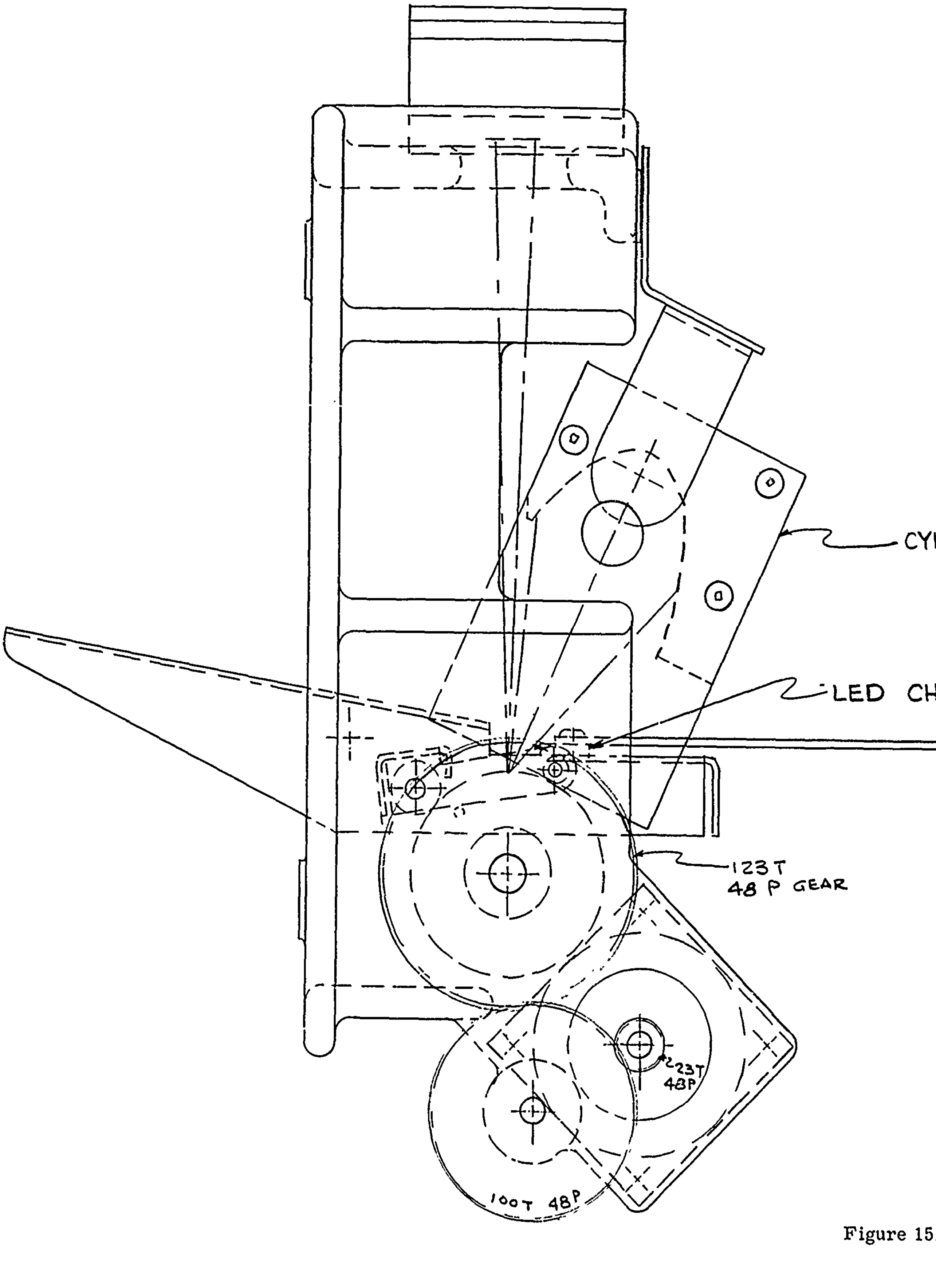


Figure 15. Optical-M

c

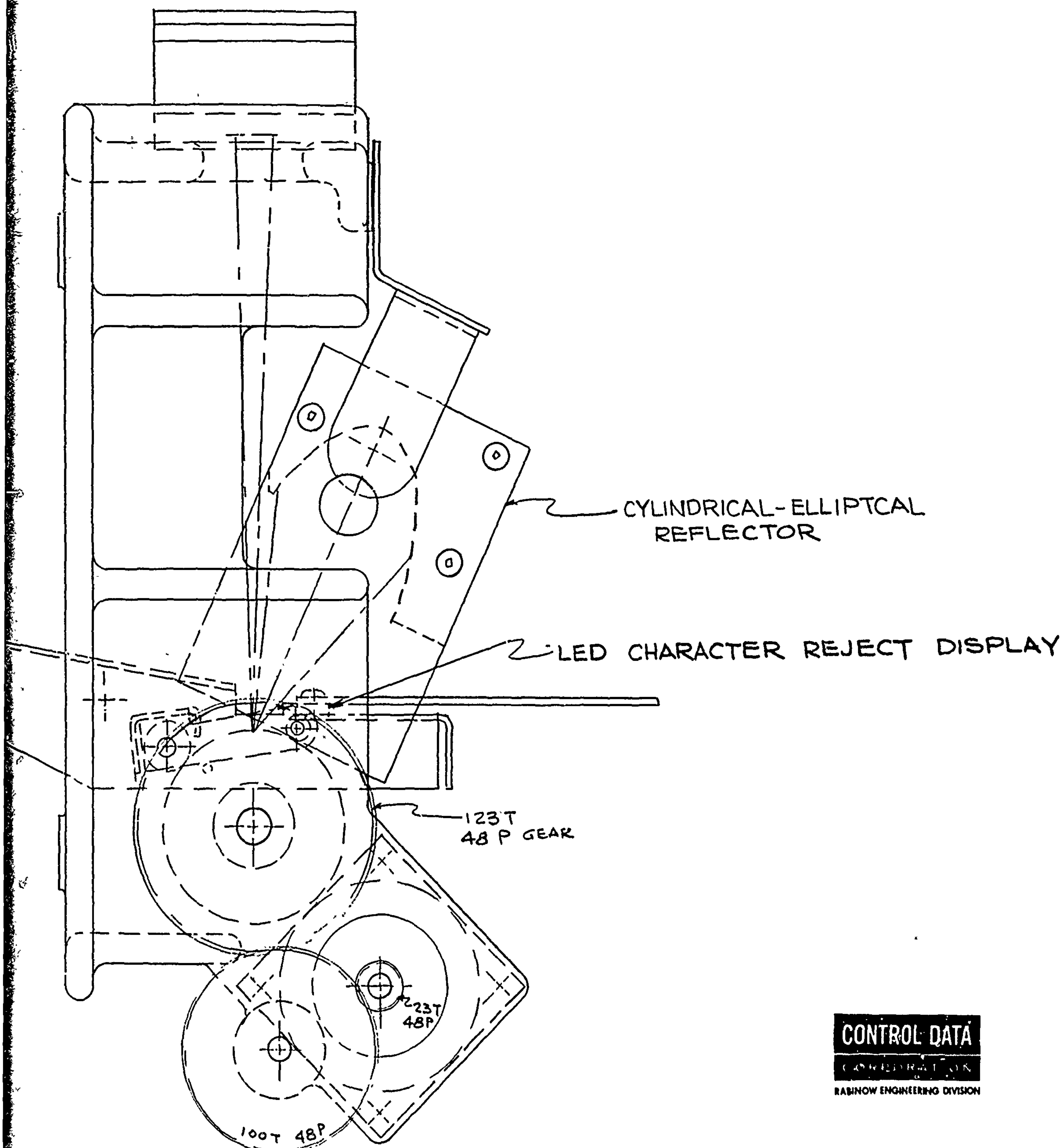
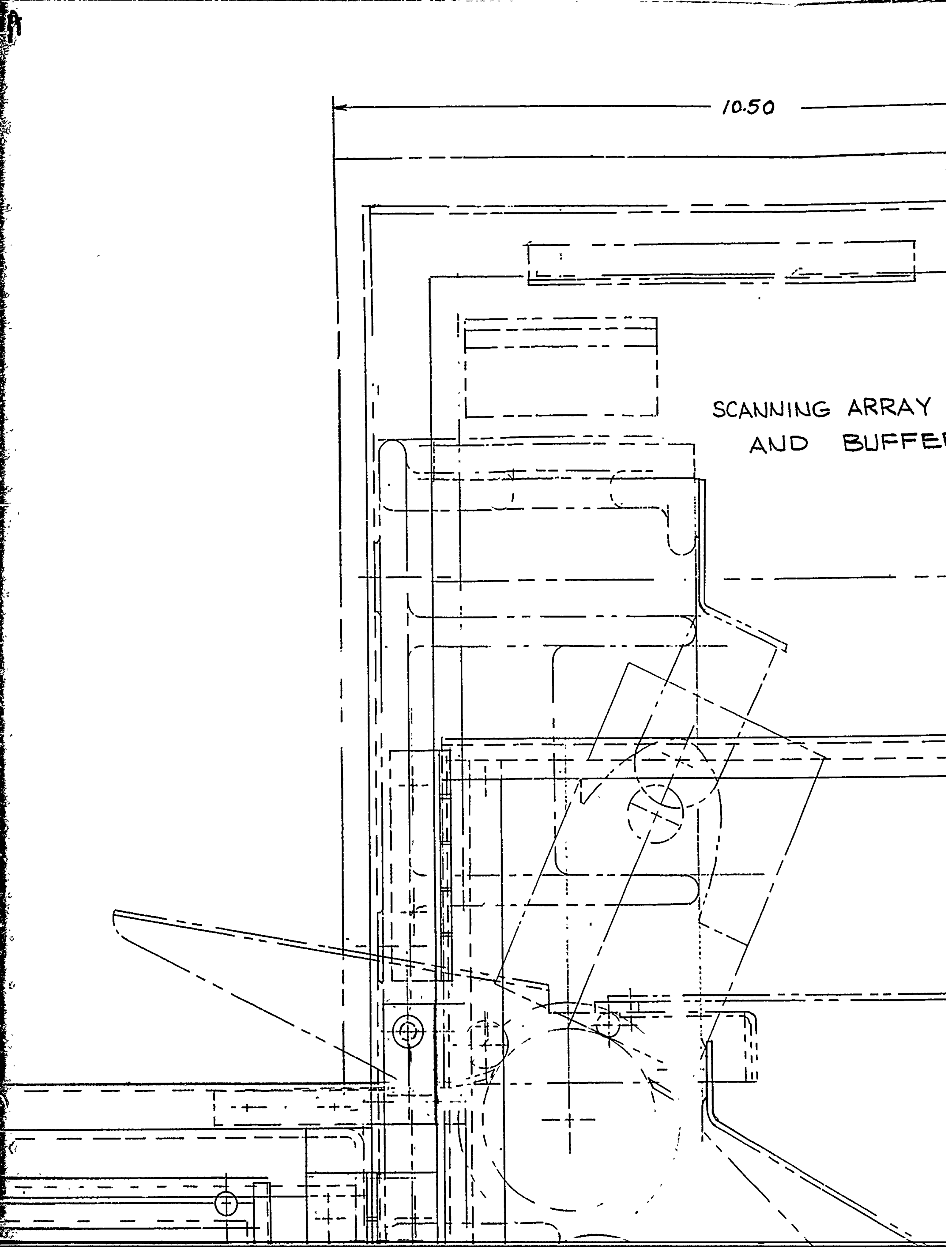
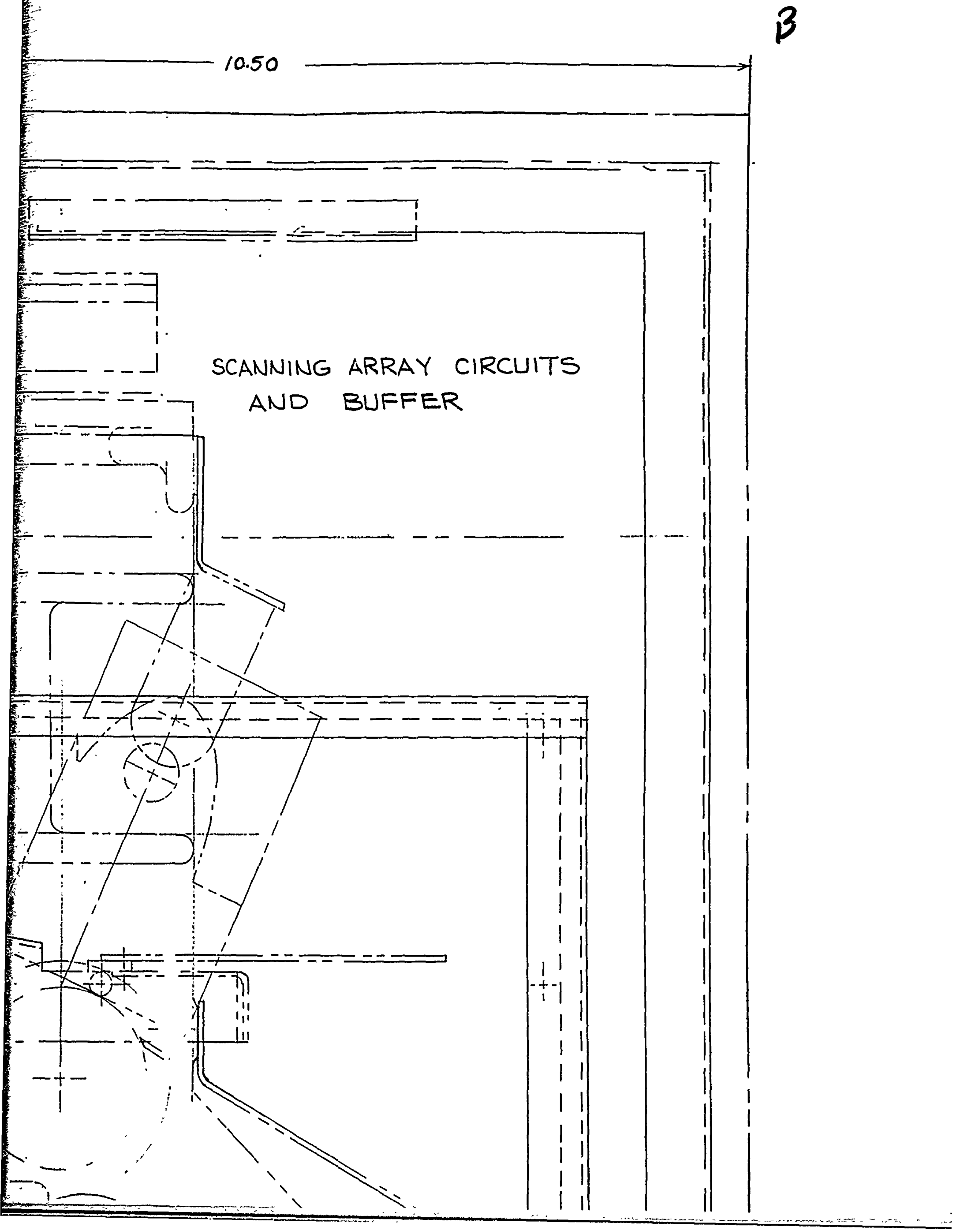
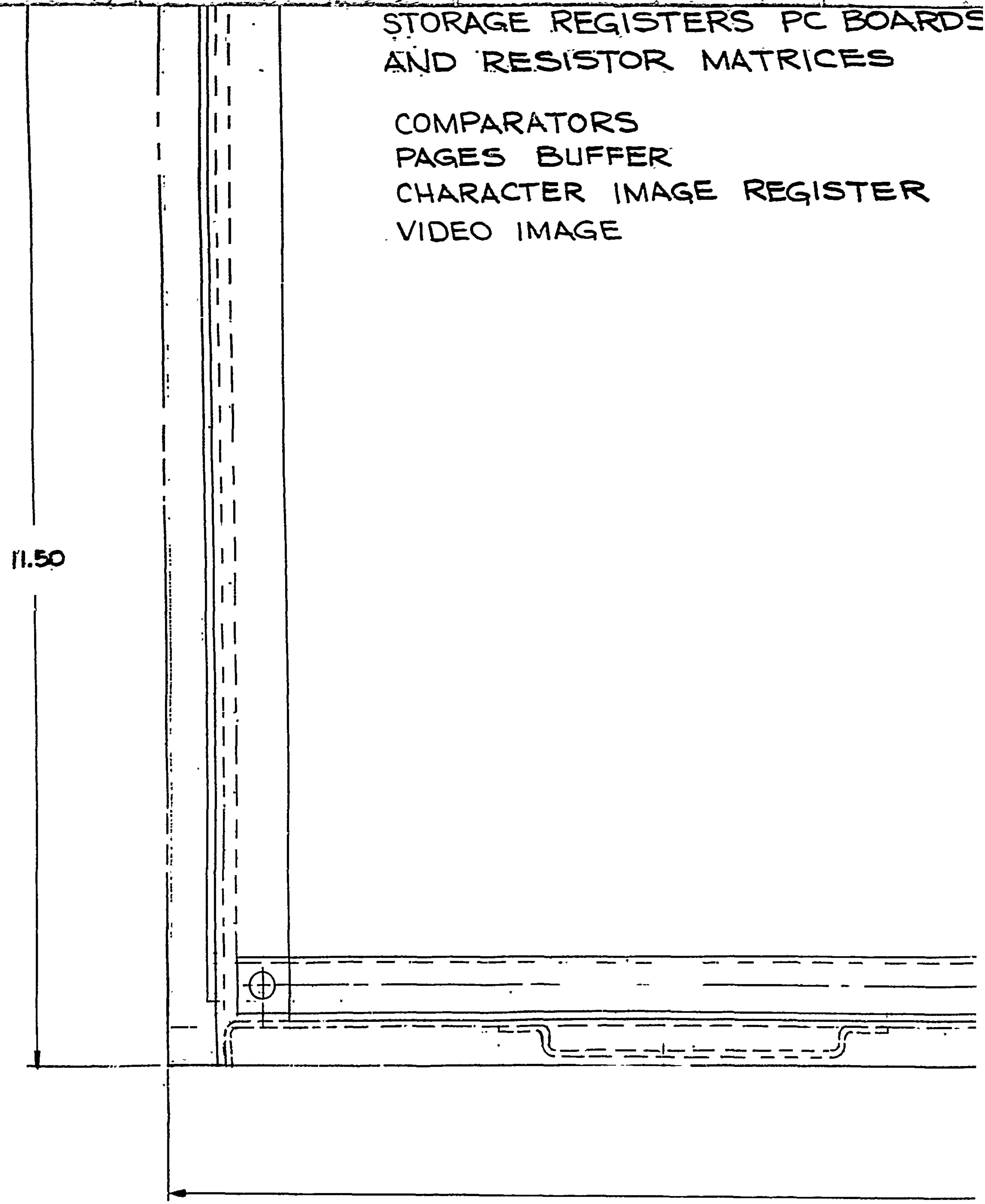
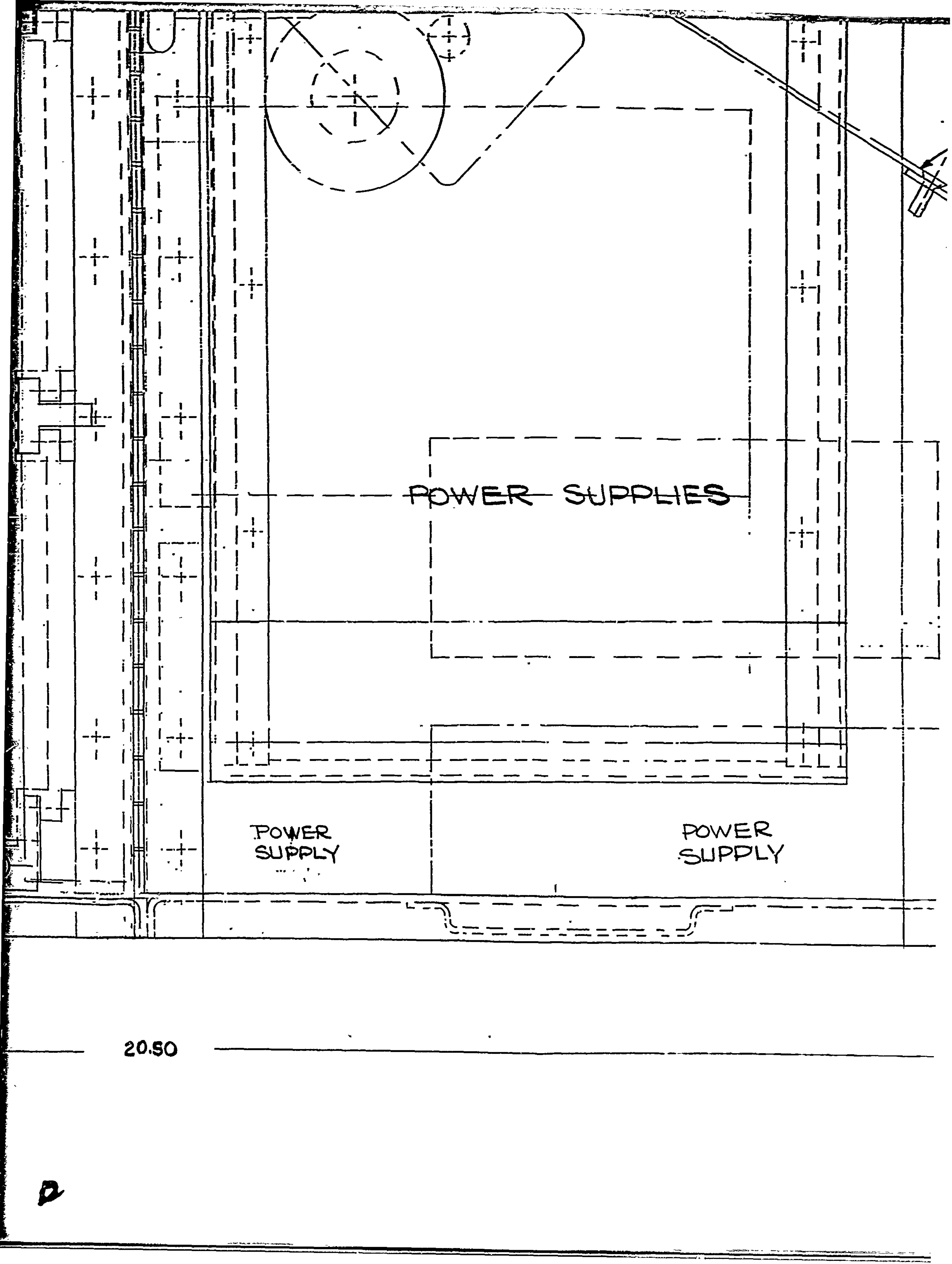


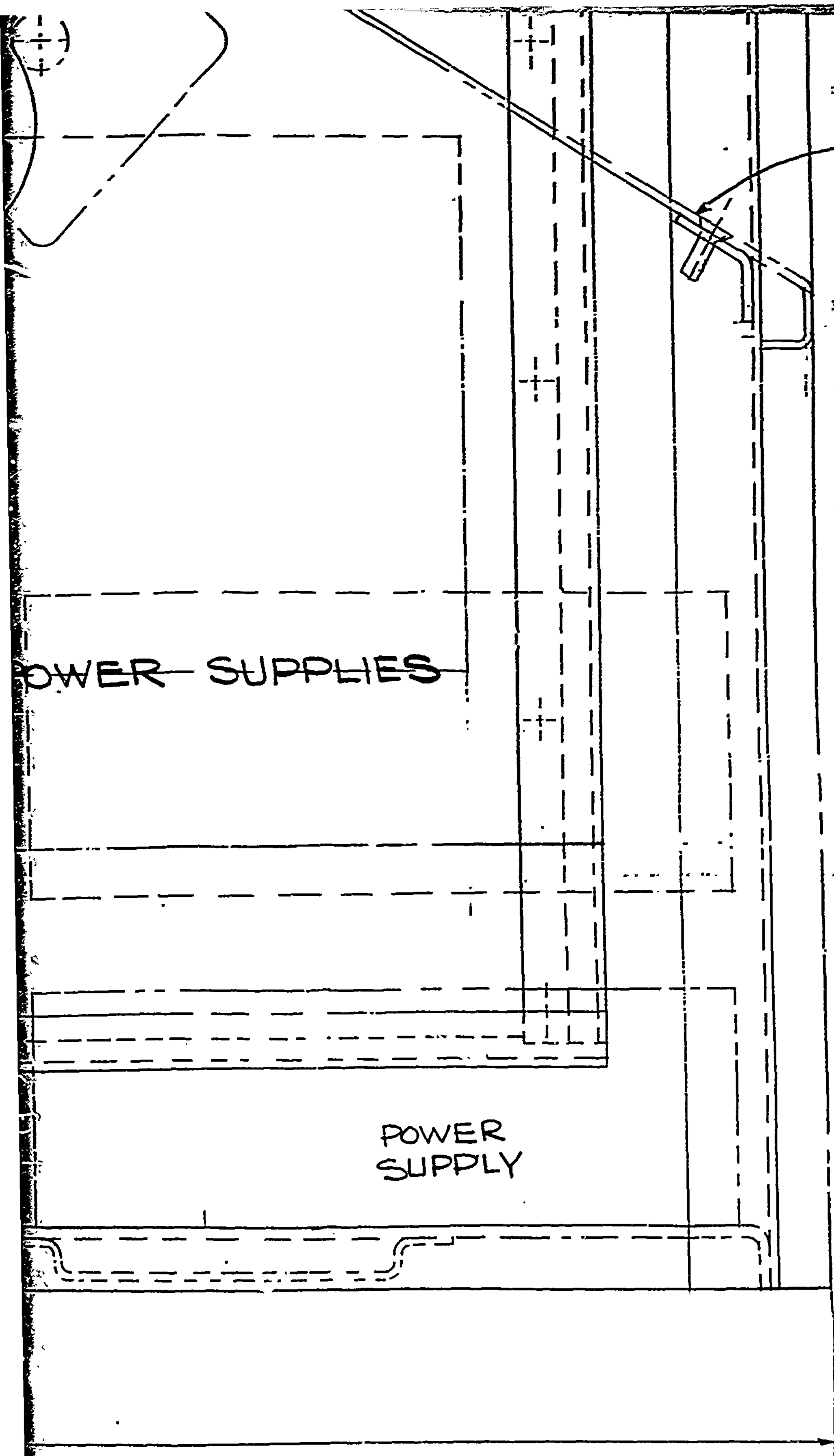
Figure 15. Optical-Mechanical Frame and Assembly


10.50
SCANNING ARRAY
AND BUFFE


B
10.50
SCANNING ARRAY CIRCUITS
AND BUFFER


STORAGE REGISTERS PC BOARDS
AND RESISTOR MATRICES
COMPARATORS
PAGES BUFFER
CHARACTER IMAGE REGISTER
VIDEO IMAGE
11.50

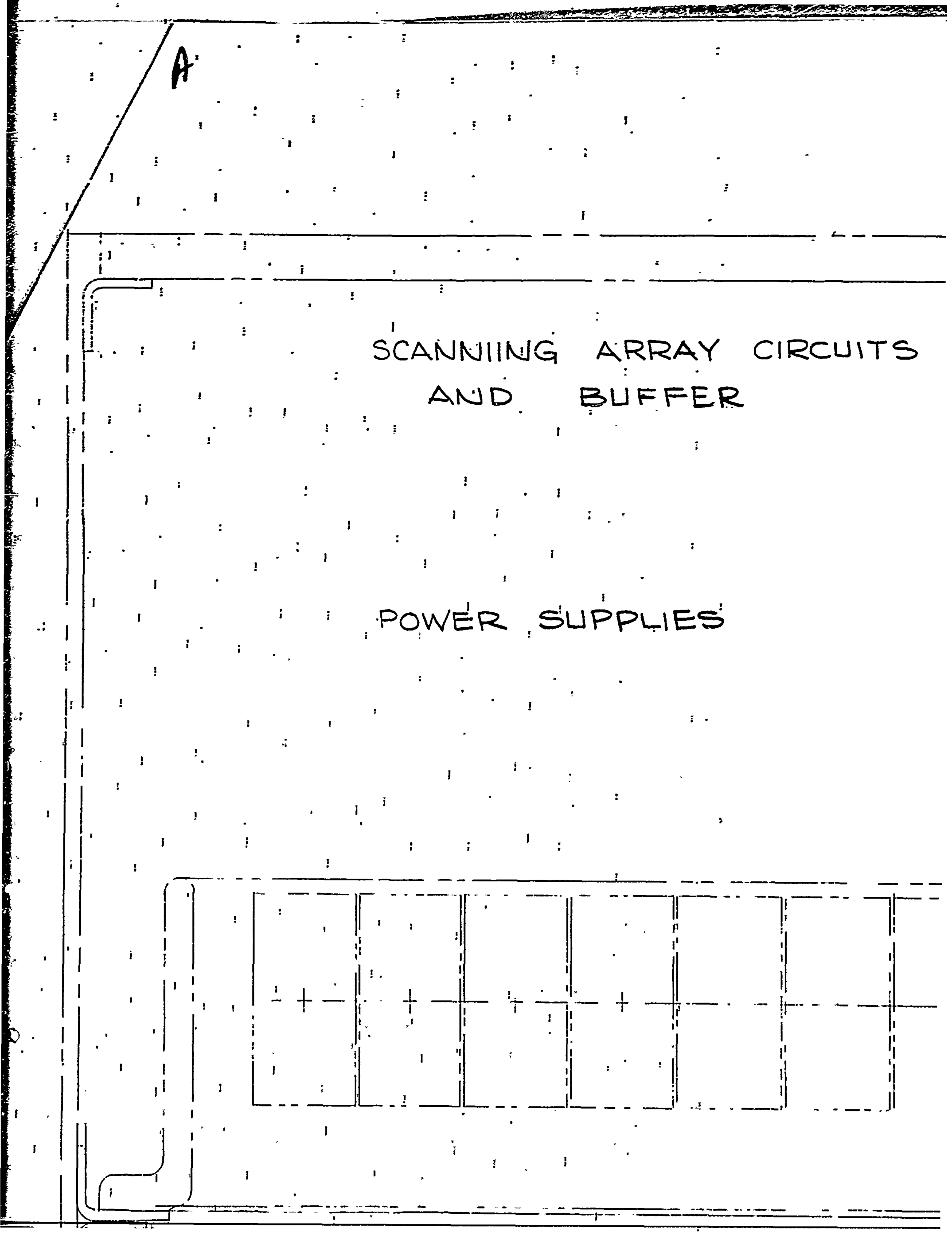

POWER SUPPLIES
POWER SUPPLY
POWER SUPPLY
20.50

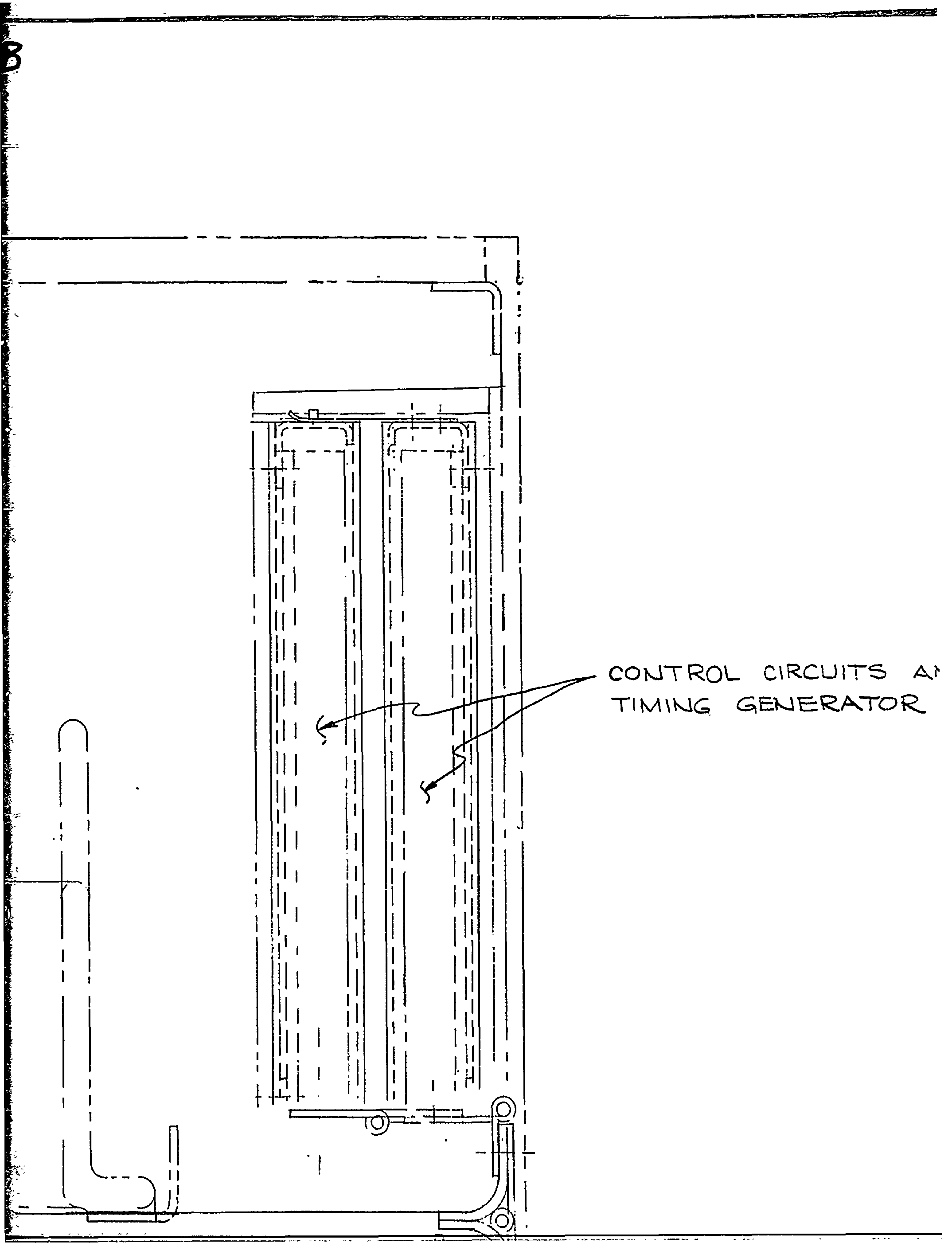


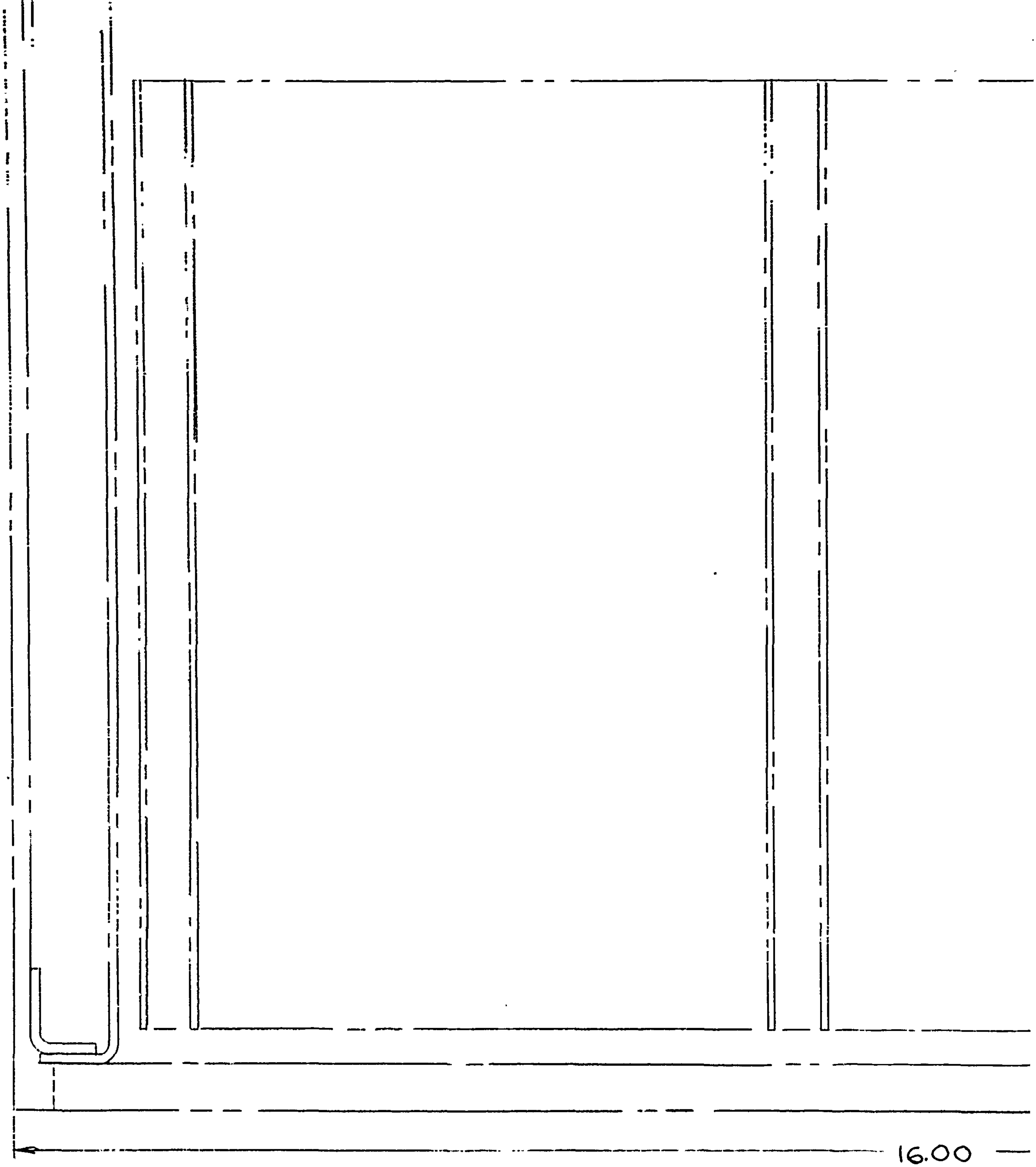
CONTROL DATA
CORPORATION
RABINOW ENGINEERING DIVISION

Figure 16. Main Frame Layout (Side View)

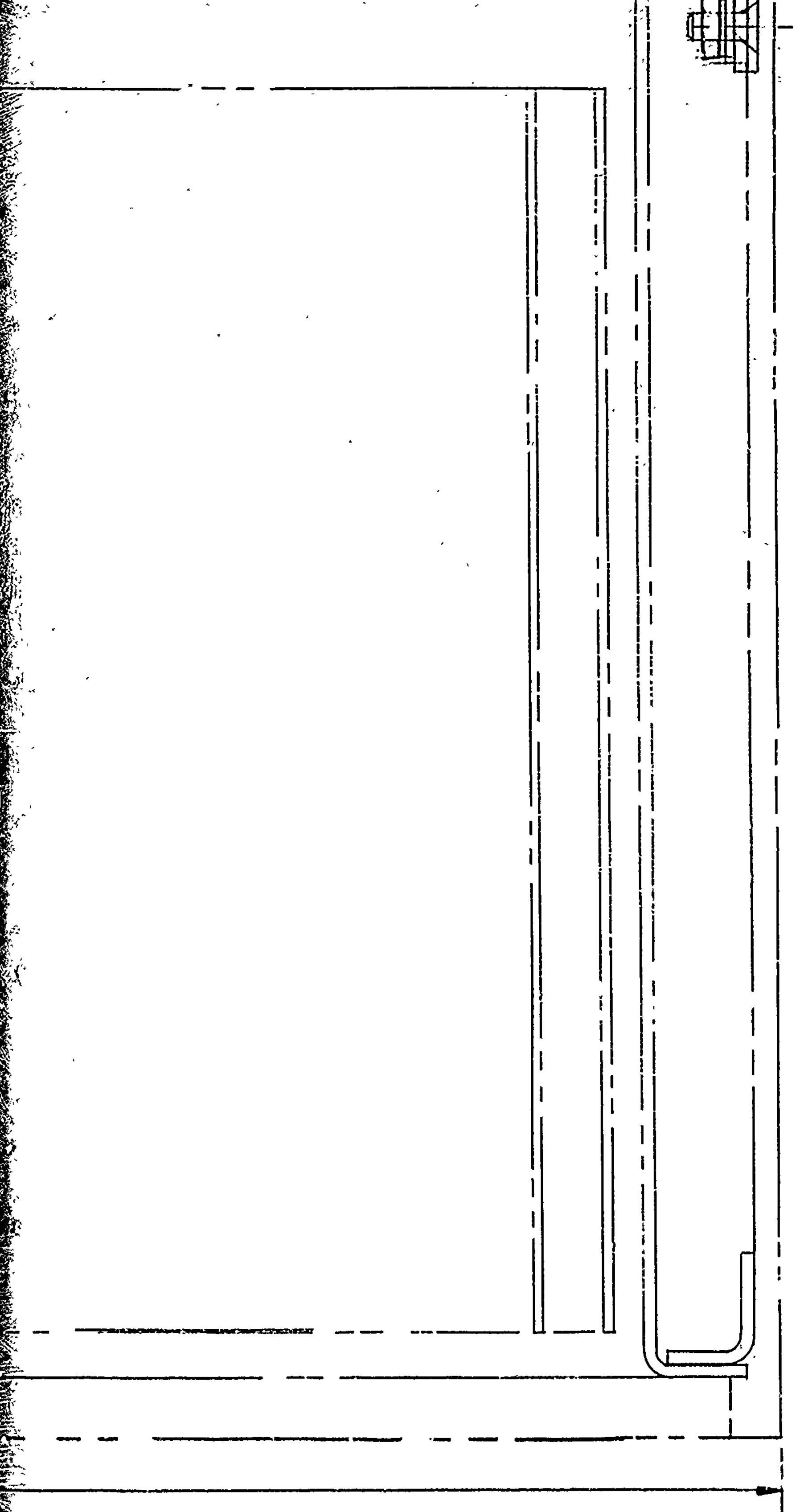
E


A
SCANNIING ARRAY CIRCUITS
AND BUFFER
POWER SUPPLIES


B
CONTROL CIRCUITS
TIMING GENERATOR

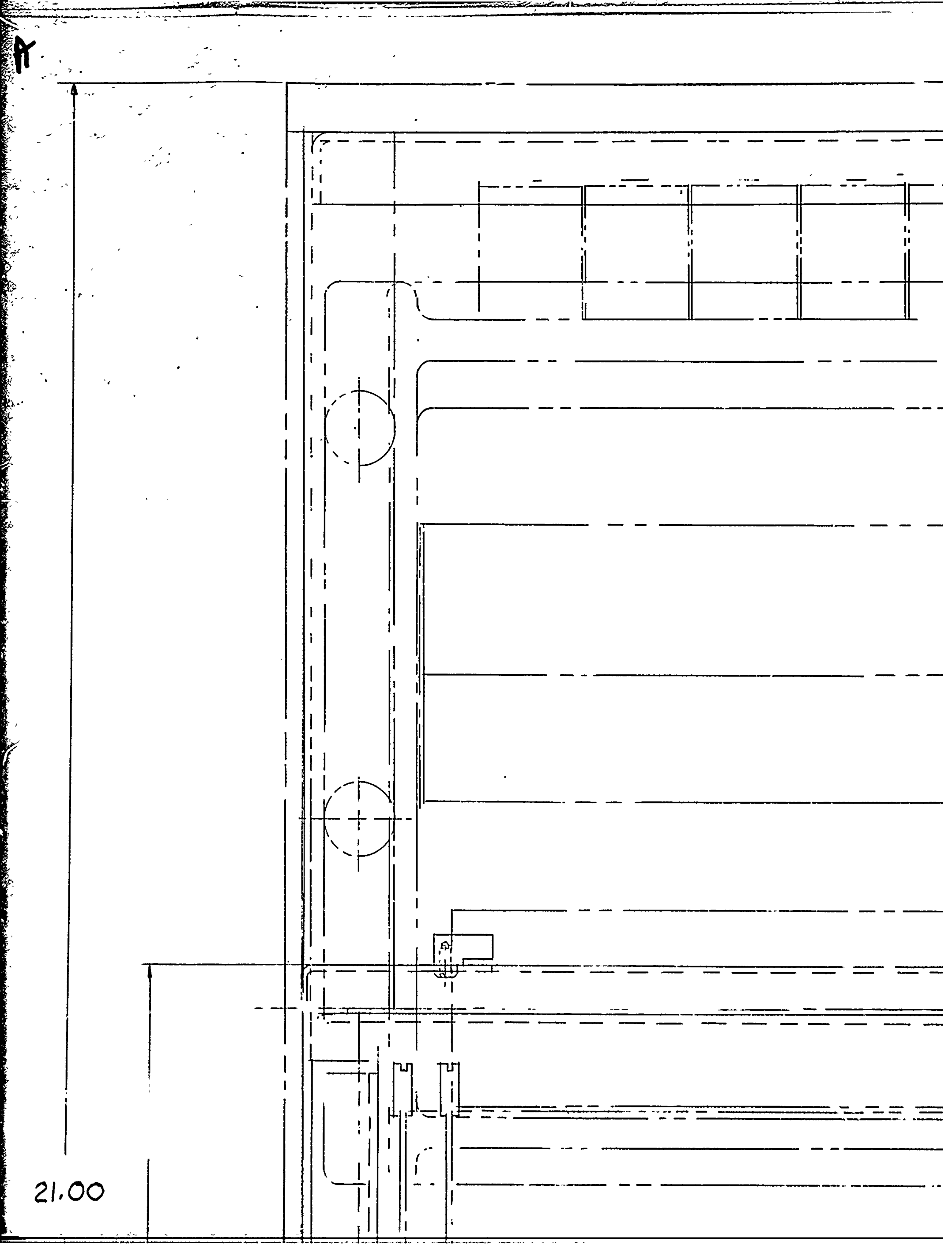


C

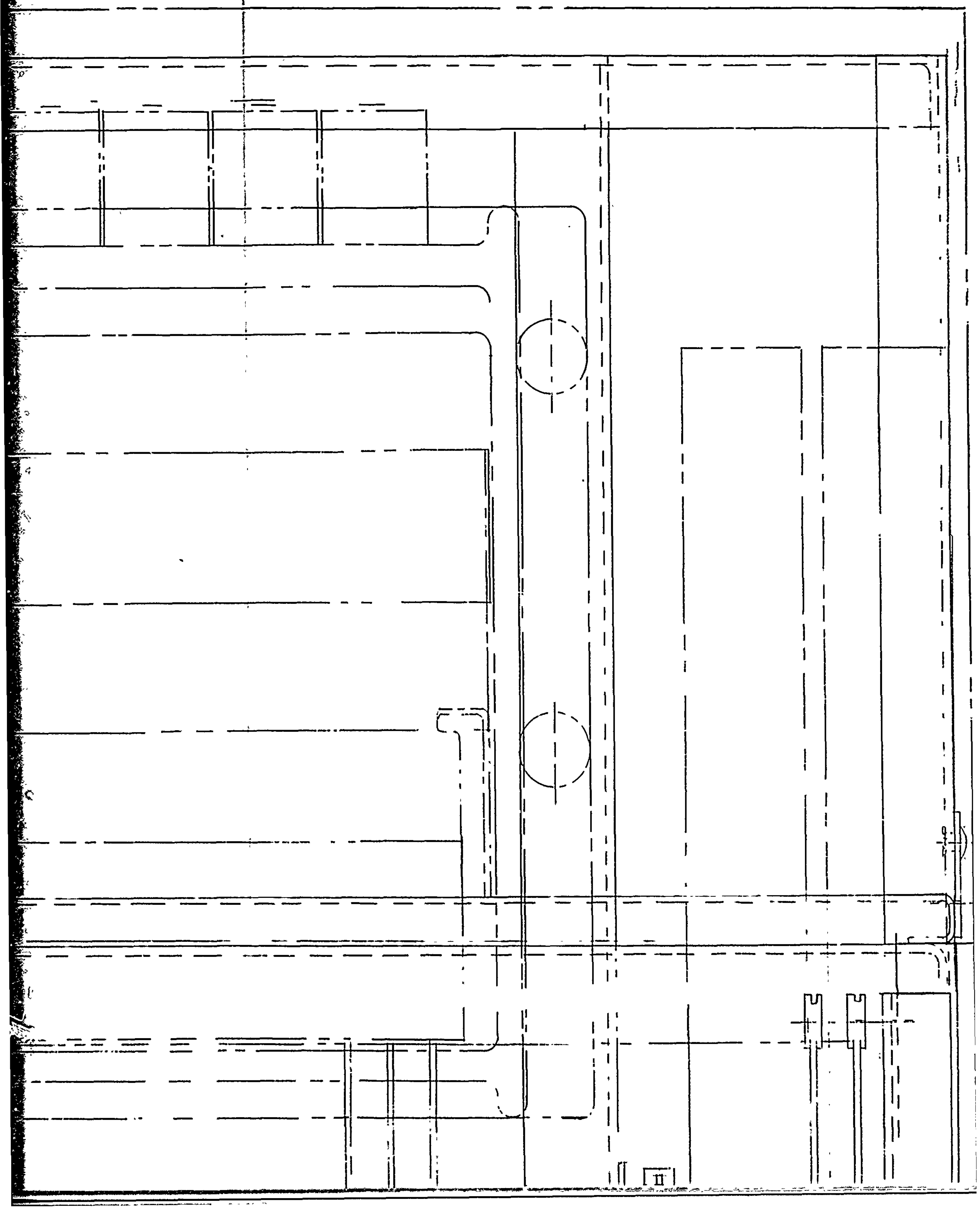


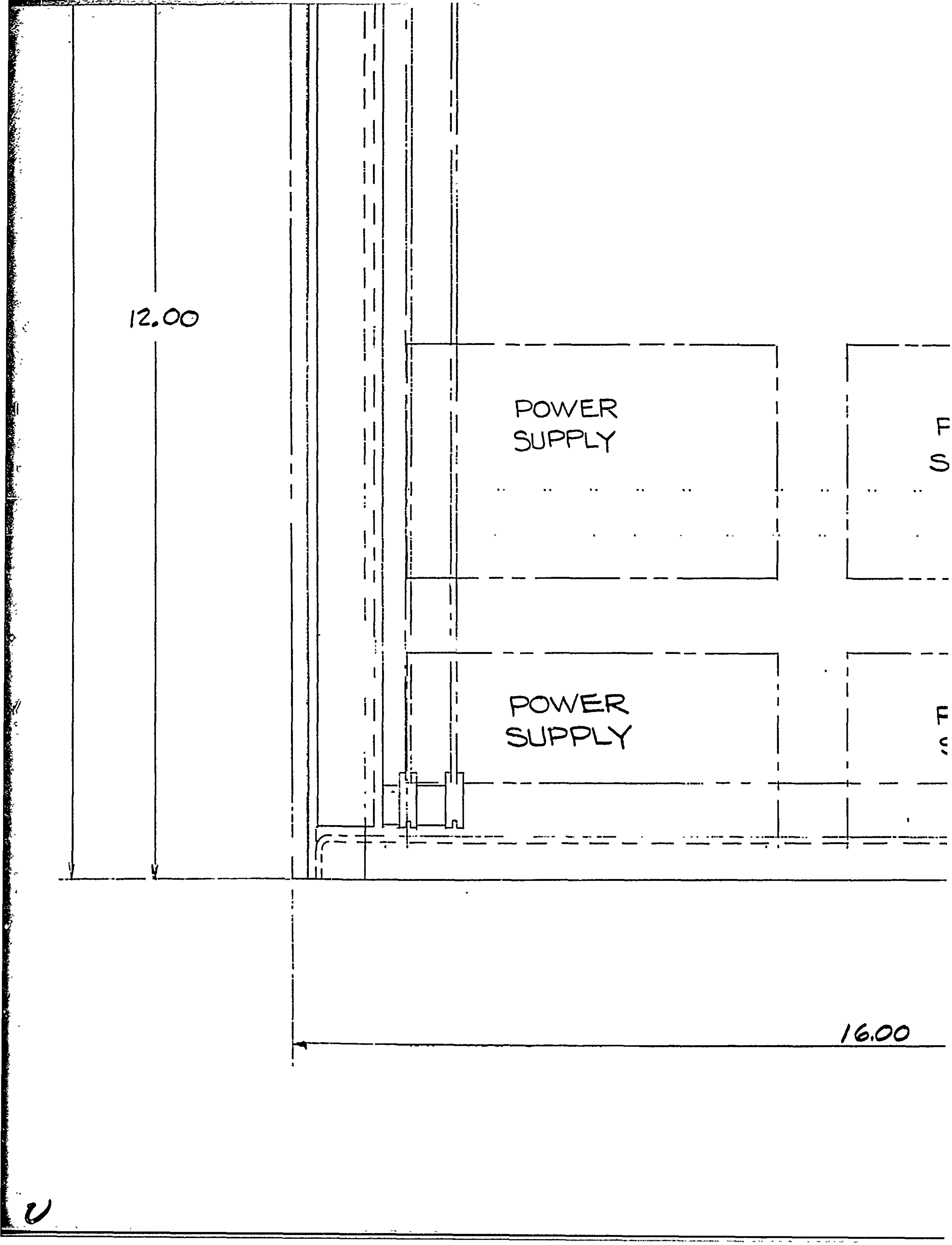
CONTROL DATA
CORPORATION
RABINOW ENGINEERING DIVISION

Figure 17. Main Frame Layout (Top V


A
21.00

D

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POWER SUPPLY
POWER SUPPLY
16.00

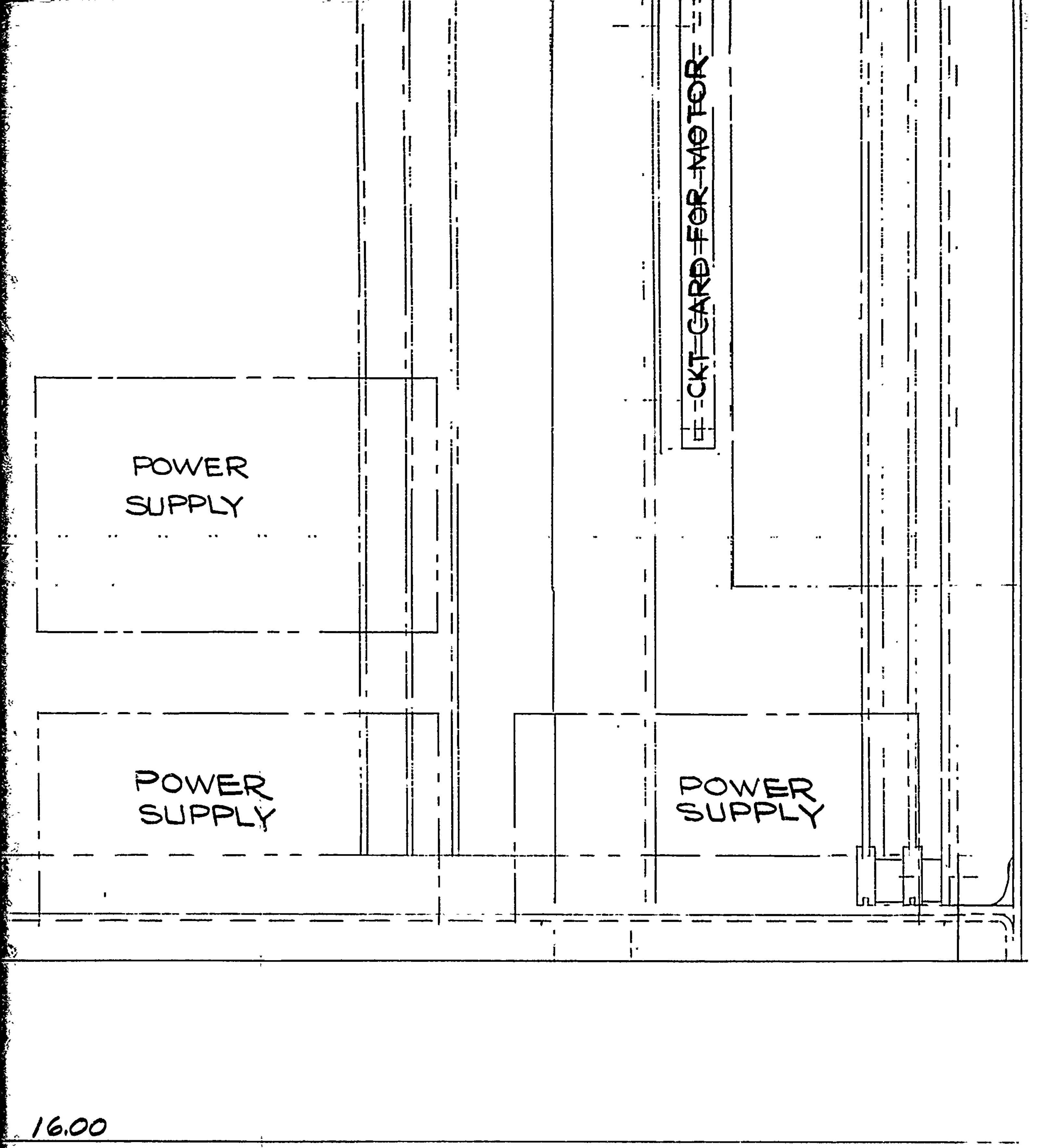

Figure 18. Main Frame Layout (Front Vie

D